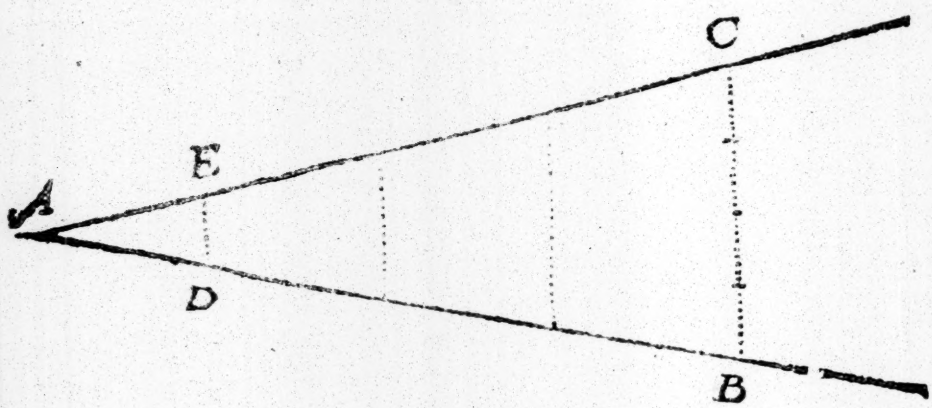
DE SECTORE & RADIO.

The deſcription and vſe of the *Sector* in three bookes.

The deſcription and vſe of the *Croſſe-Staffe* in other three bookes.

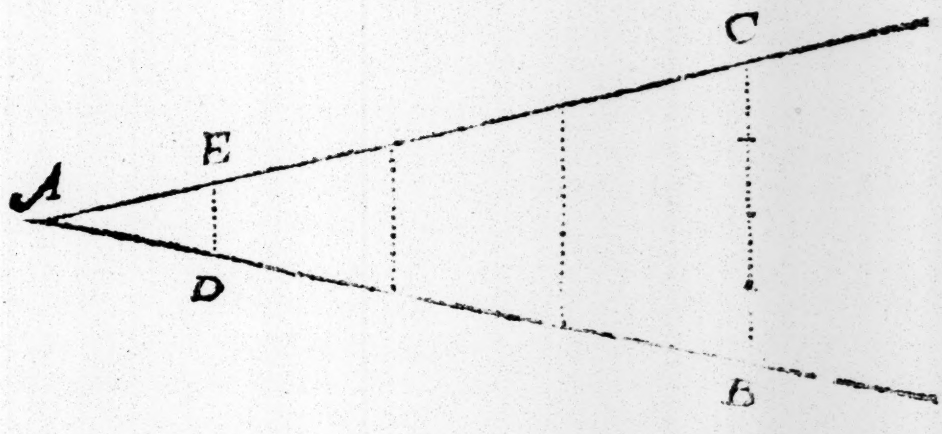
For ſuch as are ſtudious of *Mathematicall practiſe.*



LONDON,
Printed by WILLIAM IONES.
and are to be ſold by IOHN TAP at Saint
Magnus corner. 1623.

THE DESCRIPTION AND VSE OF THE SECTOR,

For ſuch as are ſtudious of *Mathematicall practiſe.*



LONDON,
Printed by WILLIAM IONES.
1623.

THE FIRST BOOKE OF THE SECTOR.

CHAP. I.

The Description, the making, and the generall vse of the Sector.

A *Sector* in Geometrie, is a figure comprehended of two right lines containing an angle at the center, and of the circumference assumed by them. This *Geometricall instrument* hauing two legs containing all varietie of angles, & the distance of the feete, representing the subtenses of the circumference, is therefore called by the same name.

It containeth 12 seuerall lines or scales, of which 7 are generall, the other 5 more particular. The first is the scale of *Lines* diuided into 100 equall parts, and numbred by 1. 2. 3. 4. 5. 6. 7. 8. 9. 10.

The second, the lines of *Superficies* diuided into 100

vnequall parts, and numbred by 1. 1. 2. 3. 4. 5. 6. 7. 8. 9. 10.

The third, the lines of *Solids*, diuided into 1000 vnequal parts, & numbred by 1. 1. 1. 2. 3. 4. 5. 6. 7. 8. 9. 10.

The fourth, the lines of *Sines* and *Chords* diuided into 90 degrees, and numbred with 10. 20. 30. vnto 90.

These foure lines of *Lines*, of *Superficies*, of *Solids*, and of *Sines*, are all drawne from the center of the *Sector* almost to the end of the legs. They are drawne on both the legs, that euery line may haue his fellow. All of them are of one length, that they may answere one to the other: And euery one hath his parallels, that the eye may the better distinguish the diuisions. But of the parallels those onely which are inward most containe the true diuisions.

There are three other generall lines, which because they are infinite are placed on the side of the *Sector*. The first a line of *Tangents*, numbred with 10. 20. 30. 40. 50. 60. signifying so many degrees from the beginning of the line, of which 45 are equall to the whole line of *Sines*, the rest follow as the length of the *Sector* will beare.

The second, a line of *Secants*, diuided by pricks into 60 degrees, whose beginning is the same, with that of the line of *Tangents*, to which it is ioyned.

The third, is the *Meridian* line, or line of *Rumbs*, diuided vnequally into degrees, of which the first 70 are almost equall to the whole line of *Sines*, the rest follow vnto 84 according to the length of the *Sector*.

Of the particular lines inserted among the generall, because there was voyd space, the first are the lines of *Quadrature* placed betweene the lines of *Sines*, and noted with 10. 9. 8. 7. S. 6. 5. 90. *Q*.

The second, the lines of *Segments* placed betweene the lines of *Sines* and *Superficies*, diuided into 50 parts, and numbered with 5. 6. 7. 8. 9. 10.

The third, the lines of *Inscribed bodies in the same Sphere*, placed betweene the scales of *Lines*, and noted with *D. S. I. C. O. T.*

The

The fourth, the lines of *Equated bodies*, placed betweene the lines of *Lines* and *Solids*, and noted with *D.I.C.S.O.T.*

The fift, are the lines of *Mettalls*, inserted with the lines of *Equated bodies* (there being roome sufficient) and noted with these Characters. ☉. ☿. ♄. ☽. ♀. ♂. ♃.

There remaine the edges of the *Sector*, and on the one I haue set a line of *Inches*, which are the twelth parts of a foote English: on the other a lesser line of *Tangents*, to which the *Gnomon* is *Radius*.

2 *Of the making of the Sector.*

Let a *Ruler* be first made either of brasse or of wood, like vnto the former figure, which may open and shut vpon his center. The head of it may be about the twelth part of the whole length, that it may beare the moueable foote, and yet the most part of the diuisions may fall without it. Then let a moueable *Gnomon* be set at the end of the moueable foote, and there turne vpon an *Axis*, so as it may sometime stand at a right angle with the feete, and sometimes be inclosed within the feet. But this is well knowne to the workeman.

For drawing of the lines. Vpon the center of the *Sector*, and semidiameter somewhat shorter then one of the feet, draw an occult arke of a circle, crossing the closure of the inward edges of the *Sector* about the letter *T*.

In this arke, at one degree on either side from the edge, draw right lines from the Center, fitting them with Parallels and diuide them into an hundred equall parts, with subdiuisions into 2. 5. or 10. as the line will beare, but let the numbers set to them, be onely 1. 2. 3. 4. &c. vnto 10. as in the example. These lines so divided, I call the lines or scales of *Lines*; and they are the ground of all the rest.

In this Arke at 5 degrees on either side, from the edge neere *T*, drawe other right lines from the Center, and fit them with Parallells. These shall serue for the lines of *Solids*.

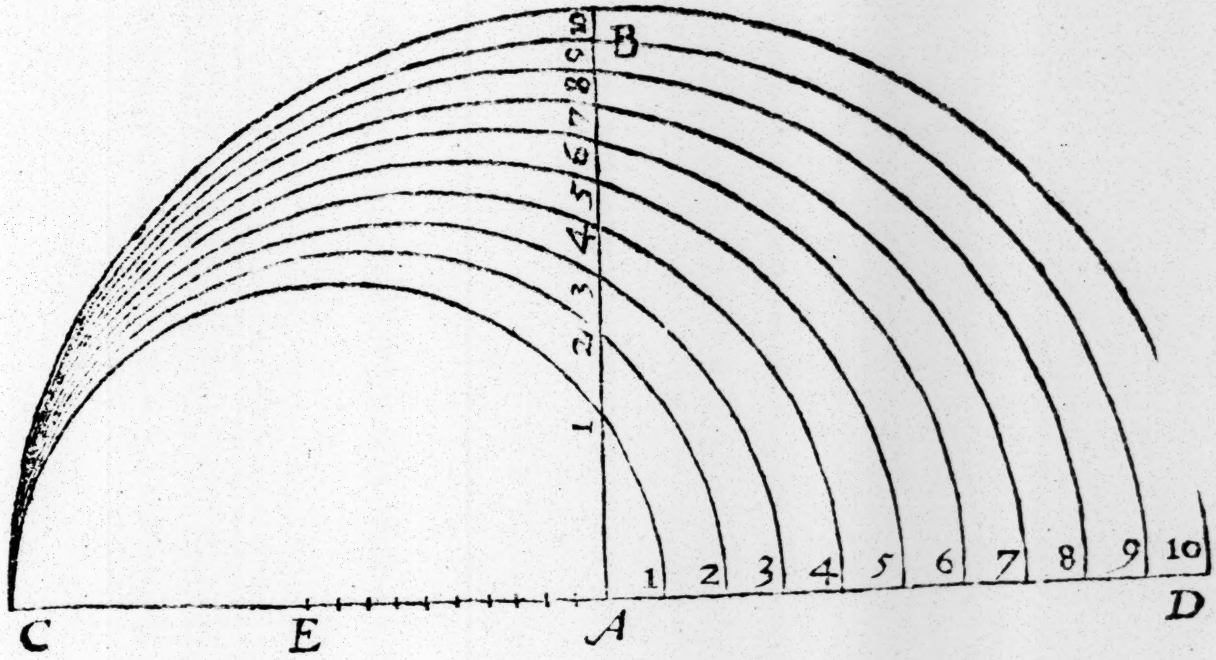
Then on the other side of the *Sector* in like manner, vpon the Center & equall Semidiameter, drawe another like Arke of a circle: & heere againe at one neere degree on either side frō the edge neere the letter *Q* draw right lines from the Center, and fit them with parallells. These shall serue for the lines of *Sines*.

At 5 Degrees on either side from the edge neere *Q* drawe other right lines from the center, and fit them with parallels: these shall serue for the lines of *Superficies*.

These foure principall lines being drawne, and fitted with parallels, we may drawe other lines in the middle betweene the edges and the lines of *Lines*, which shall serue for the lines of *inscribed bodies*, and others betweene the edges and the *Sines* for the lines of *quadrature*. And so the rest as in the example.

3 *To diuide the lines of* Superficies.

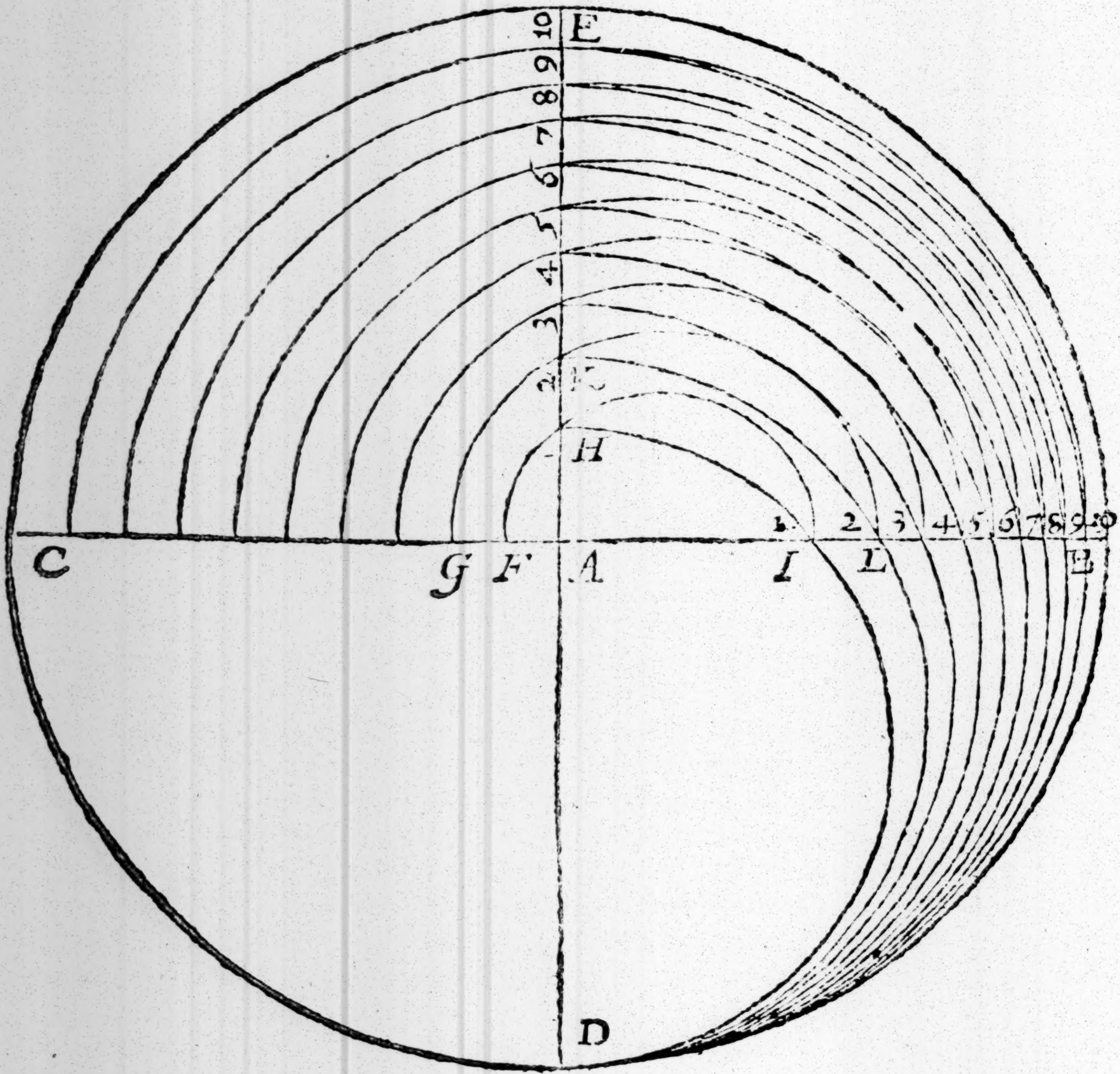
SEeing like *Superficies* doe hold in the proportion of their *homologall* sides duplicated, by the 29 Pro. 6 lib. *Euclid*. If you shall find meane proportionals betweene the whole side, and each hundred part of the like side, by the 13 Pro. 6 lib. *Euclid*. all of them cutting the same line, that line so cut shal conteine the diuisions required. wherefore vpon the center *A* and Semidiamiter equall to the line of *Lines*, describe a Semicircle *A C B D*, with *A B* perpendicular to the diameter *C D*. And let the Semidiameter *AD* be diuided as the line of *Lines* into an hundred parts, & *A E* the one halfe of *AC* diuided also into an hundred parts, so shall the diuisions in *A E* be the centers from whence you shall describe the Semicircles *C 10*. *C 20*. *C 30*. &c. diuiding the lin *A B* into an hundred vnequall parts: and this line *A* B so diuided shall be the line of *Superficies*, and must be transferred into the *Sector*. But let the numbers set to them be onely 1. 1. 2. 3. vnto 10. as in the example.



4 *To diuide the lines of* Solids.

SEing like Solids do hold in the proportion of their *homologall* sides triplicated, if you shall finde two meane proportionalls betweene the whole side & each thousand part of the like side : all of them cutting the same two right lines, the former of those lines so cut, shall containe the diuisions required.

Wherefore vpon the center *A* & Semidiameter equall to the line of *Lines*. describe a circle and diuide it into 4 equall parts *C E B D*, drawing the crosse diameters *C B*, *E D*. Then diuide the semidiameter *A C*, first into 10 equall parts, and betweene the whole line *A D* & *A F* the tenth part of *A C*, seeke out two meane proportionall lines *A I* and *A H*. againe betweene *A D* and *A G* being two tenth parts of *A C*, seeke out two meane proportionals *A L* and *A K*, and so forward in the rest. So shall the line *A B* be diuided into 10 vnequall parts.



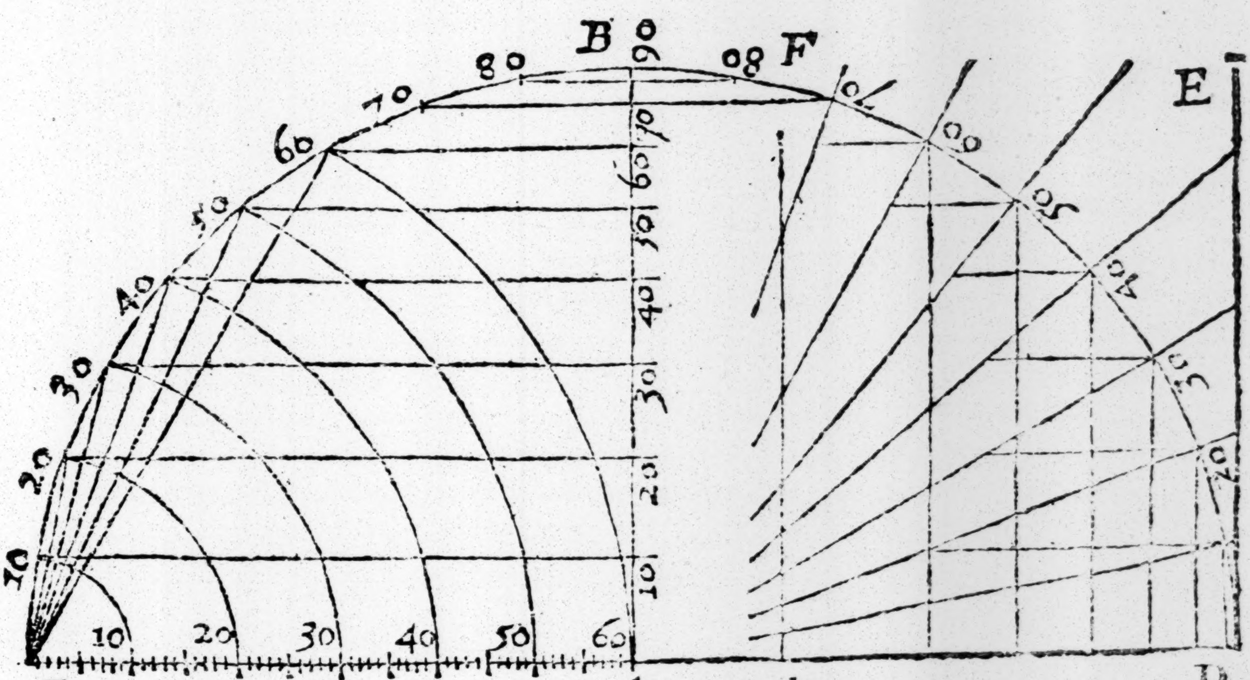
Secondly, diuide each tenth part of the line *AC* into 10 more, and betweene the whole line *AD*, and each of them, seeke out two meane proportionalls as before: So shall the line *AB* be diuided now into an hundred vnequall parts.

Thirdly, If the length will beare it, subdiuide the line *AC* once againe, each part into ten more: and betweene the whole line *AD* and each subdiuision, seeke two meane

meane proportionalls as before. So ſhould the line *AB* be now diuided into 1000 parts. But the ruler being ſhort, it ſhall ſuffice, if thoſe 10 which are neareſt the center be expreſſed, the reſt be vnderſtood to be ſo diuided, though actually they be diuided into no more then 5 or 2. and this line *AB* ſo diuided ſhall be the line of *Solids*, and muſt be transferred into the *Sector*: But let the numbers ſet to them be onely 1. 1. 1. 2. 3. &c. vnto 10. as in the example.

5 *To diuide the lines of* Sines *and* Tangents *on the ſide of the Sector.*

VPon the center *A*, and ſemidiameter equall to the line of *Lines*, deſcribe a ſemicircle *A B C* D, with *A B*, perpendicular to the diameter C D. Then diuide the quadrants *C B*, *B* D, each of them into 90. and ſubdiuide each degree into 2 parts: For ſo, if ſtreight lines be drawne parallell to the diameter *C* D, through theſe 90, and their ſubdiuiſions they ſhall diuide the perpendicular *A* E vnequally into 90.



And this line A B so diuided shall be the line of ***Sines***; and must be transferred into the ***Sector***. The numbers set to them are to be 10. 20. 30. &c. vnto 90 as in the example.

If now in the poynt *D*, vnto the diameter *C D*, we shall raise a perpendicular *D E*, and to it drawe streight lines from the center *A*, through each degree of the quadrant D B. This perpendicular so diuided by them shall be the line of ***Tangents***, & must be transferred vnto the side of the ***Sector***. The numbers set to them, are to be 10. 20 30. &c. as in the example.

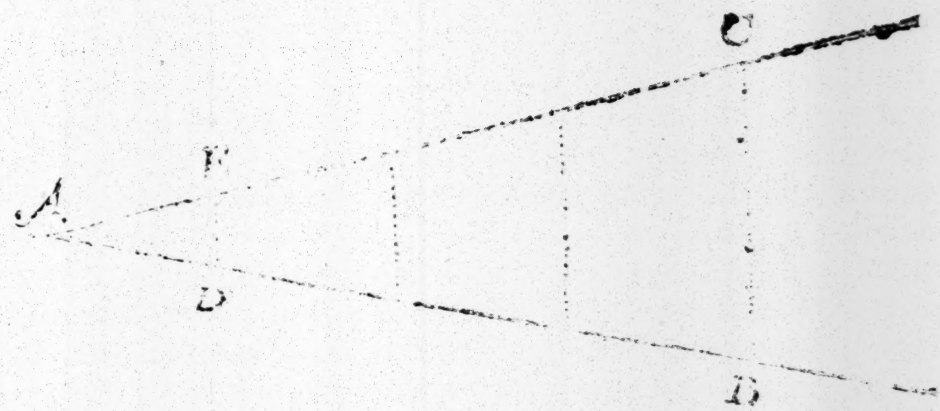
If betweene A and D, another streight line *G F*, be drawne parallell to D E, it will be diuided by those lines from the center in like sort as D E is diuided, and it may serue for a lesser line of ***Tangents***, to be set on the edge of the *Sector*.

These lines of ***Sines*** and ***Tangents***, may yet otherwise be transferred into the ***Sector*** out of the line of ***Lines***, (or rather out of a diagonall Scale equall to the line of ***Lines***) by tables of Sines and Tangents. In like manner may the lines of ***Superficies***, be transferred by tables of square rootes; and the line of ***Solids***, by tables of cubique rootes: which I leaue to others to extract at leasure.

6 *To shew the ground of the Sector.*

Let A B, A C, represent the leggs of the ***Sector***: then seuering these two A B, A C, are equall, and their sections A D, A E, also equall, they shall be cut proportionally: and if we draw the lines B C, D E, they will be parallell by the second Pro. 6 lib. of ***Euclid***, and so the Triangles A B C, A D E, shalbe equiangle; by reason of the common angle at A, and the equall angles at the base, and therefore shall haue the sides proportionall about those equall angles, by the 4 Pro. 6 lib. of ***Euclid***.

The



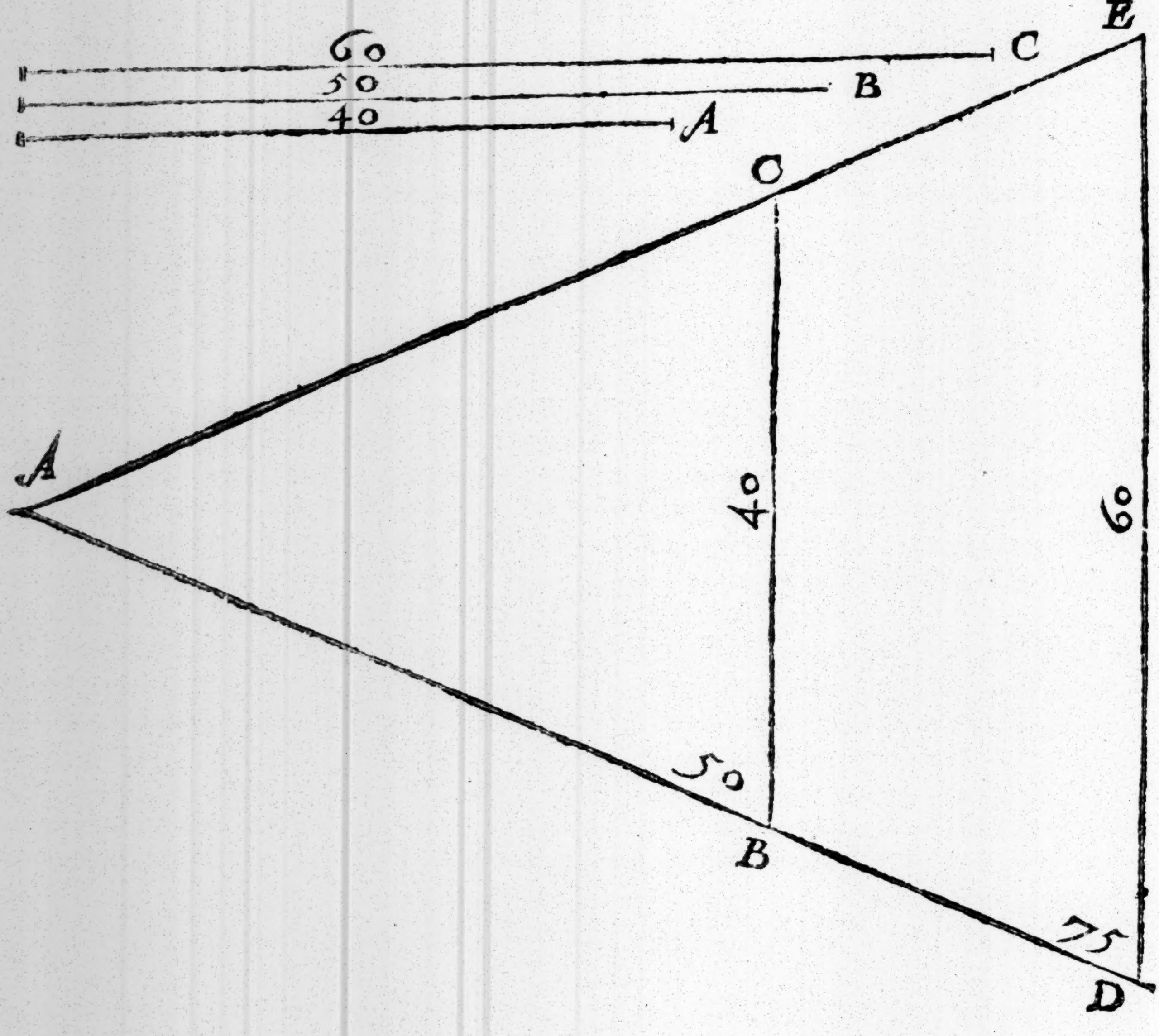
The side A D, shalbe to the side A B, as the basis D E, vnto the parallell basis BC, and by conuersion A B, shall be vnto A D, as B C, vnto D E: and by permutation A D, shall be vnto D E, as A B, to B C.&c. So that if A D, be the fourth part of the side A B, then D E, shall also be the fourth part of his parallell basis B C. The like reason holdeth in all other sections.

7 To shew the generall vse of the Sector.

There may some cōclusions be wrought by the *Sector*, euen then when it is shut, by reason that the lines are all of one length: but generally the vse hereof consists in the solution of the *Golden rule*, where three lines being giuen of a known denominaton, a fourth proportionall is to be found. And this solution is diuerse in regard both of the *lines*, and of the *entrance* into the worke.

The solution in regard of the *lines* is sometimes *simple*, as when the worke is begun and ended vpon the same *lines*. Sometimes it is compound, as when it is begun on one kind of *lines*, and ended on another. It may be begun vpon the lines of *Lines*; & finished vpon the lines of *Superficies*. It may begin on the *Sines*, and end on the *Tangents*.

The ſolution in regard of the *entrance* into the worke, may be either with a *parallell* or elſe *laterall* on the ſide of the Sector, I cal it *parallell entrance*, or entring with a parallell, when the two lines of the firſt denomination are applied in the parallells, and the third line, and that which is ſought for, are on the ſide of the *Sector*. I call it *laterall entranse*, or entring on the ſide of the *Sector*, when the two lines of the firſt denomination are one the ſide of the *Sector*, and the third line and that which is to be found out, doe ſtand in the parallells.

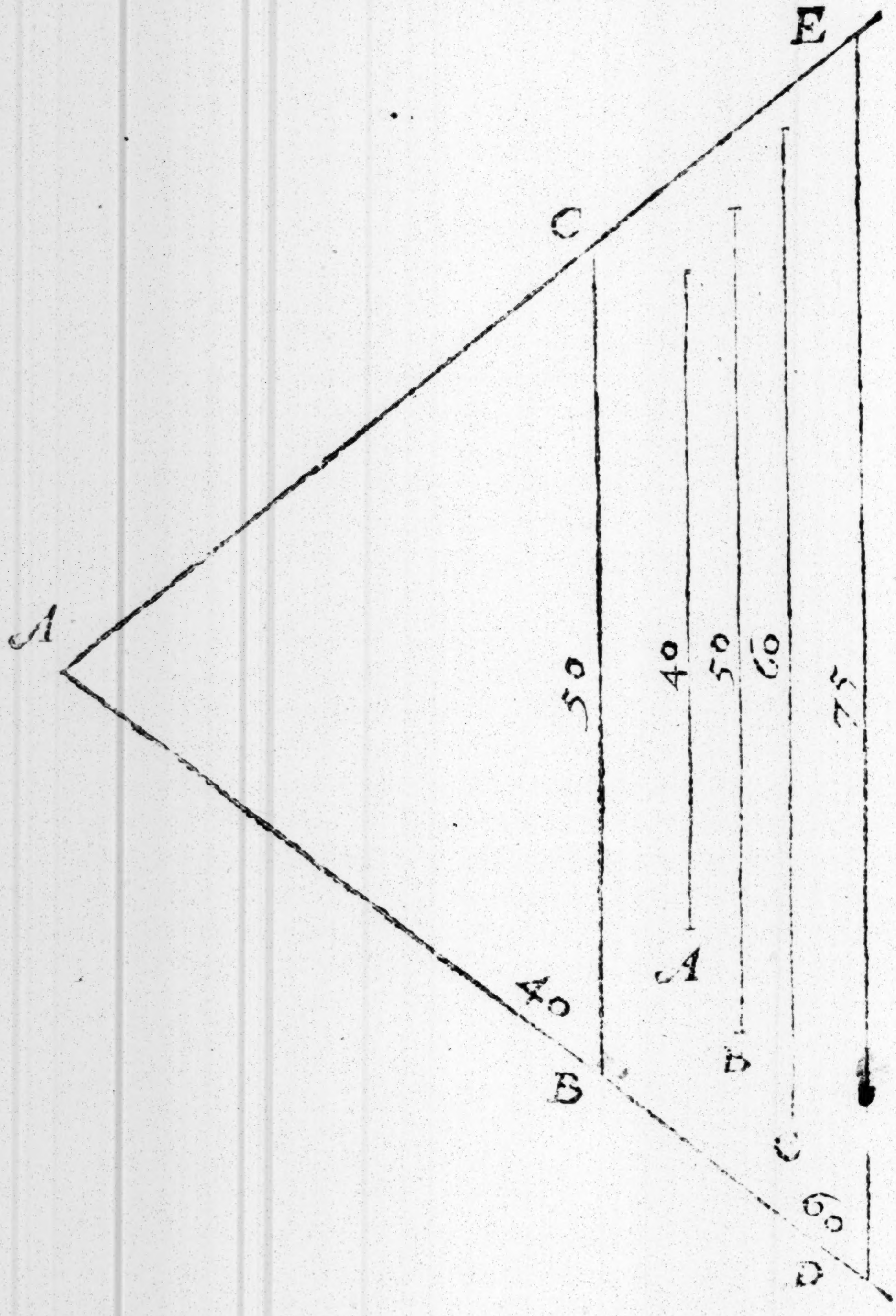


As for example, let there be giuen three lines A, B, C, to which I am to find a fourth proportionall. let A, measured in the line of *lines*, be 40, B 50, and C 60, and suppose the question be this. If 40 *Monthes* giue 50 *pounds*, what shal 60? Here are lines of two denominatiõs, one of *months*, another of *pounds*, and the first with which I am to enter must be that of 40 *monthes*. If then I would *enter with a parallell*, first I take A, the line of 40, and put it ouer as a *parallell* in 50, reckoned in the line of *lines*, on either side of the *Sector* from the center, so as it may be the Base of an *Isoscbeles* triangle B A C, whose sides A B, A C are equal to B, the line of the second denomination.

Then the *Sector* being thus opened, I take C the line of 60, betweene the feete of the compasses, and carrying them *parallell* to B C, I finde them to crosse the lines A B, A C, on the side of the *Sector* in D and E, numbred with 75, wherefore I conclude the line A D, or A E, is the fourth proportionall and the correspondent number 75 which was required.

But if I would *enter on the side* of the *Sector*, then would I dispose the lines of the first denomination A and C, in the line of *Lines*, on both sides of the *Sector*, in A B, A C, & in A D, A E, so as they should all meete in the center A, and then taking B the line of the second denominati onput it ouer as a *parallell* in B C, that it may be the Basis of the Isocheles triangle B A C, whose sides A B, A C, are equall to A, the first line of the first denomination, for so the *Sector* being thus opened, the other *parallell* from D to E, shall be the fourth proportionall which was required, and if it be measured with the other lines, it shal be 75, as before.

In both this manner of operations, the two first lines do serue to opē the *Sector* to his due angle, the difference betweene them is especially this, that in *parallell entrance*, the two lines of the first denomination, are placed in the parallells B, C, D, E, & in *latterall entrance* they are placed on both sides of the *Sector*, in A B, A D and in A C, A E.



Now in *ſimple ſolution* which is begun and ended, vpon the ſame kinde of lines, it is allone which of the two latter lines be put in the ſecōd or third places. As in our exāple we may ſay, as 40 are to 50, ſo 60 vnto 75, or elſe as 40 are to 60, ſo 50 vnto 75. And hence it cōmeth that we may enter both with a *parrallell*, & on the ſides two manner of wayes at either entrance, and ſo the moſt part of queſtions may

may be wrought 4 ſeuerall wayes, though in the propoſitions following, I mention onely that which is moſt conuenient. Thus much for the generall vſe of the *Sector*, which being conſidered and well vnderſtood, there is nothing hard in that which followeth.

CHAP. II.

The vſe of the Scale of Lines.

1. *To ſet downe a Line, reſembling any giuen parts or fraction of parts.*

THe lines of *Lines* are diuided actually into 100 parts, but we haue put onely 10 numbers to them. Theſe we would haue to ſignifie either themſelues alone, or ten times themſelues, or an hundred times themſelues, or a thouſand times themſelues, as the matter ſhall require. As if the numbers giuen be no more then 10, then we may thinke the lines onely diuided into 10 parts according to the numbers ſet to them. If they be more then 10, and not more then 100, then either line ſhall containe 100 parts, and the numbers ſet by them ſhall be in value 10. 20. 30. &c. as they are diuided actually. If yet they be more then 100, then euery part muſt be thought to be diuided into 10, and either line ſhall be 1000 parts, and the numbers ſet to them ſhall be in value 100. 200. 300, and ſo forward ſtill increaſing themſelues by 10. This being preſuppoſed, we may number the parts and fraction of parts giuen in the line of *lines*; and taking out the diſtance with a paire of compaſſes, ſet it by, for the line ſo taken ſhall reſemble the number giuen.

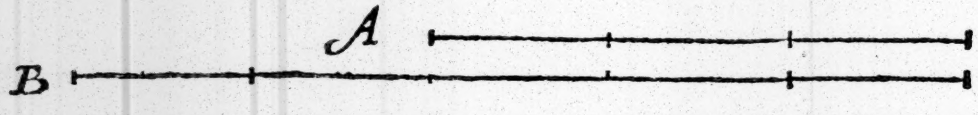
In this manner may we ſet downe a line reſembling 75, if either we take 75 out of the hundred parts, into which one of the line of *lines* is actually diuided, and note it in A, or 7½. of the firſt 10 parts, and note it in B, or onely ¾. of one of thoſe hundred parts, and note it in C. Or

if this be either to great or to small, we may run a Scale at pleasure, by opening the compasse to some small distance, and running it ten times ouer, then opening the compasse to these ten, run them ouer nine times more, & set figures to them as in this example, and out of this we may take what parts we will as before.

To this end I haue diuided the line of inches on the edge of the *Sector*, so as one inch containeth 8 parts, another 9, another 10, &c. according as they are figured, and as they are distant from the other end of the *Sector*, that so we might haue the better estimate.

2 *To encrease a line in a giuen proportion.*
3 *To diminish a line in a giuen proportion.*

Take the line giuen with a paire of compasses, and open the *Sector*, so as the feete of the compasses may stand in the points of the number giuen, then keeping the *Sector* at this angle, the parallell distance of the points of the number required, shall giue the line required.



Let *A*, be a line giuen to be increased in the proportion of 3 to 5. First I take the line *A*, with the compasses, and open the *Sector* till I may put it ouer in the poynts of 3 and 3, so the parallell betweene the poynts of 5 & 5, doth giue me the line *B*, which was required.

In like manner, if *B*, be a line giuen to be diminished in the proportiō of 5 to 3, I take the line *B* & to it open the *Sector* in the poynts of 5, so the parallell betweene the points of 3, doth giue me the line *A*, which was required.

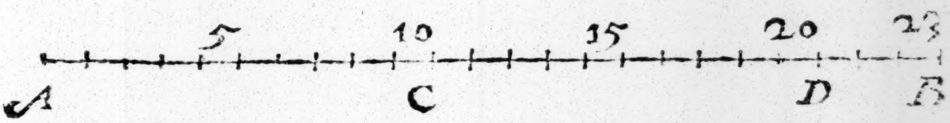
If this manner of worke doth not suffice, we may multiplie or diuide the numbers giuen by 1, or 2, or 3, &c. And so worke by their numbers *equimultiplices*, as for 3 and

and 5, wee may open the *Sector* in 6 and 10, or else in 9 and 15, or else in 12 and 20, or in 15 and 25, or in 18 and 30. &c.

4 *To diuide a line into parts giuen.*

TAke the line giuen, and open the *Sector* according to the length of the said line in the points of the parts, wherevnto the line should be diuided, then keeping the *Sector* at this angle, the parallell distance betweene the points of 1 and 1 shall diuide the line giuen into the parts required.

Let A B, be the line giuen to be diuided into fiue parts, first I take this line A B, and to it open the *Sector* in the points of 5 and 5, so the parallell betweene the points of 1 and 1, doth giue me the line A C, which doth diuide it into the parts required.



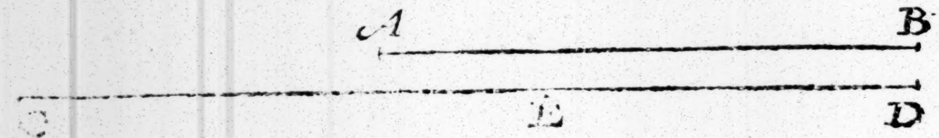
Or let the like line A B, be to be diuided into twenty three parts. First I take out the line and put it vpon the *Sector* in the points of 23, then may I by the former proposition diminish it in A C, C D, in the proportion of 23, to 10, and after that diuide the line A C into 10, &c. As before.

5 *To finde a proportion betweene two or more right lines giuen.*

TAke the greater line giuen, and according to it open

the

the *Sector* in the points of 100 and 100, then take the leſſer lines ſeuerally, & carry them parallell to the greater, till they ſtay in like points, ſo the number of points wherein they ſtay, ſhall ſhew their proportion vnto 100.



Let the lines giuen be *AB*, *CD*, firſt I take the line *CD*, & to it open the *Sector* in the points of 100, and 100, then keeping the *Sector* at this angle, I enter the leſſer line *A B*, parallell to the former, and find it to croſſe the lines of *Lines* in the poynts of 60. Wherefore the proportion of *A B* to *C D*, is as 60 to 100.

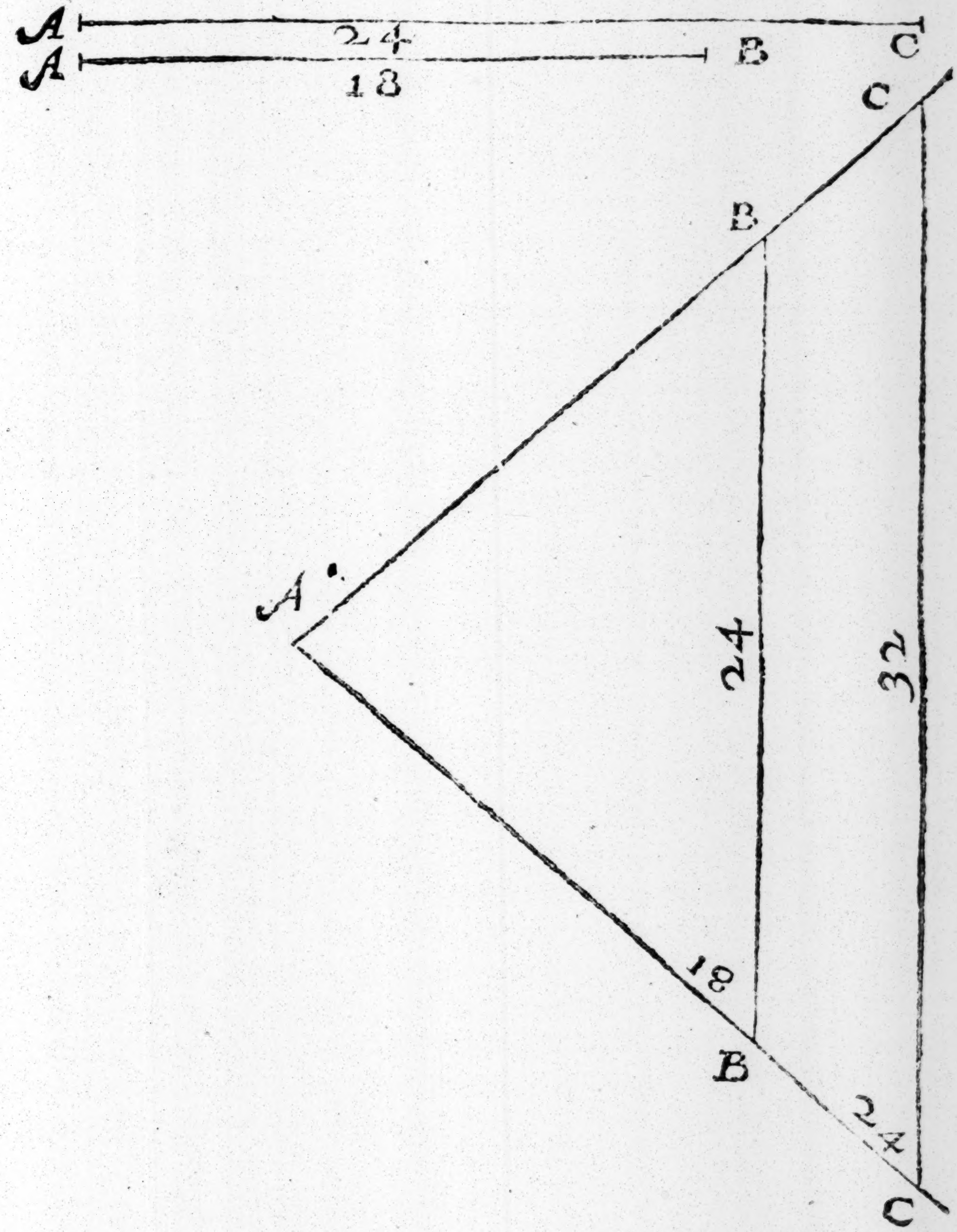
Or if the line *C* D, be greater then can be put ouer in the poynts of 100, then I admit the leſſer line *A B*, to be 100, & cutting off *CE* equal to *A B*, I find the proportion of *C E*, vnto *E* D, to be as 100, almoſt to 67; wherefore this way ẏ proportiõ of *AB* vnto *C*D, is as 100 vnto almoſt 167.

This propoſition may alſo not vnfitly be wrought by any other number, that admits ſeuerall diuiſions, and namely, by the numbers of 60. And ſo the leſſer line will be found to be 36, which is as before in leſſer numbers, as 3 vnto 5. It may alſo be wrought without opening the *Sector*. For if the lines betweene which we ſeek a proportion, be applyed to the lines of *Lines*, (or any other Scale of equall parts) there will be ſuch proportiõ found between them, as betweene the lines to which they are equall.

6 *Two lines being giuen to finde a third in continuall proportion.*

First place both the lines giuen, on both ſides of the *Sector* from the Center, and marke the termes of their extenſion, then take out the ſecond line againe, and to it open the *Sector*, in the terme of the firſt line, ſo keeping the

the *Sector* at this angle, the parallell distance betweene the termes of the second line, shall be the third proportionall.

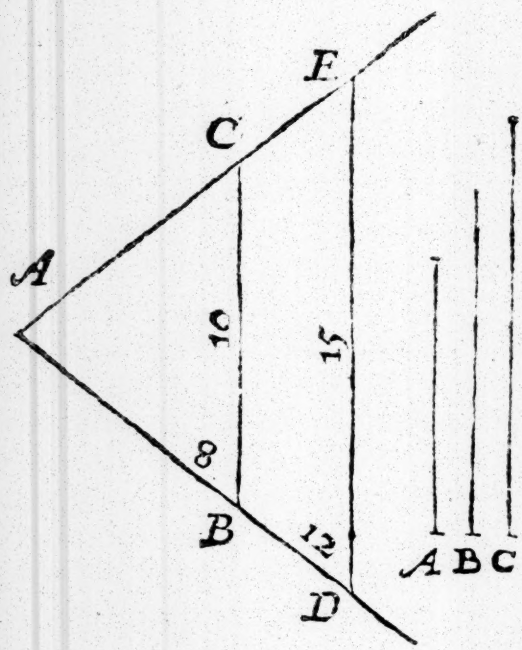


Let the two lines giuen be A B, A C, which I take out and place on both sides of the *Sector*, so as they all meete in the center A, let the termes of the first line be B and B, the termes of the second C and C. Then doe I take out A C the second line againe, and to it open the *Sector* in the termes B B. So the parallell betweene C and C doth giue me the third line in continuall proportion. For as *A B* is vnto *A C*, so BB, equall to *A C*, is vnto *C C*.

7 *Three lines being giuen to finde the fourth in discontinuall proportion.*

HEre the first line and the third are to be placed on both sides of the *Sector* from the center, then take out the second line, and to it open the *Sector* in the termes of the first line. For so keeping the *Sector* at this angle, the parallell distance betweene the termes of the third line, shalbe the fourth proportionall.

Let the three lines giuen be A, B, C.



First I take out A and C, and place them on both sides of the *Sector*, in A B, A C, and A D, A E, laying the beginning of both lines at the center A, then do I take out B the second line, according to it I open the *Sector* in B and C, the termes of the first line: so the parallell betweene D and E, doth giue me the fourth proportionall which was required.

As in *Arithmetique*, it sufficeth if the first and third number giuen be of one denomination, the second & the fourth which is required be of another. For one and the same denomination is not required necessarily in them all. So in *Geometrie*, it sufficeth if the sides A B, A D, resembling the first

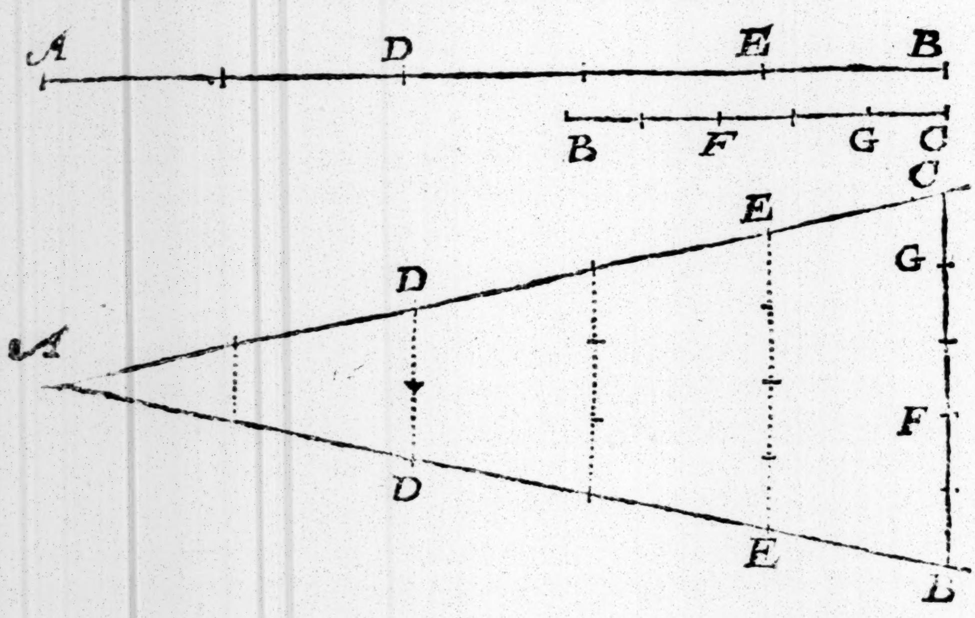
firſt and third lines giuen be meaſured in one Scale, and the parallells B C, D E be meaſured in another. Wherefore knowing the proportion of A the firſt line, and C the third line, by the fift *prop.* before. Which is here as 8 to 12, & deſcẽding in leſſer numbers is as 4 to 6, or as 2 to 3, or aſcending in greater numbers, as 16 vnto 24, or 18 to 27, or 20 to 30, or 30 to 45, or 40 to 60 &c. If the *Sector* be opened in the points of 8 and 8, to the quantity of *B*, the ſecond line giuen, then a parallell betweene 12 and 12, ſhall giue D E, the fourth line required. So likewiſe if it be opened in 4 and 4, then a parallell betweene 6 and 6, or if in 16 and 16, then a parallell betweene 24 and 24 ſhall giue the ſame D E. And ſo in the reſt.

8 *To diuide a line in ſuch ſort as another line is before diuided.*

First take out the line giuen, which is already diuided, and laying it on both ſides of the *Sector* from the center, marke how farre it extendeth. Then take out the ſecond line which is to be diuided, and to it open the *Sector* in the termes of the firſt line. This done, take out the parts of the firſt line, and place them alſo on the ſame ſide of the *Sector* from the center. For the parallells taken in the termes of theſe parts, ſhalbe the correſpondent parts in the line which is to be diuided.

Let *A B*, be a line diuided in *D* and *E*, and *B C*, the line which I am to diuide in ſuch ſort, as *A B* is diuided.

Firſt I take out the line *A B*, and place it on the line of *Lines* in *A B*, *A C*, both from the center *A*, then take I out the ſecond *B C*, and to it open the *Sector* in *B* and *C*, the termes of the firſt line. The *Sector* thus opened to his due angle, I take out *A D* and *A E*, the parts of the firſt line *A B*, and place them alſo on both the ſides of the *Sector* in *A D*, *A E*, ſo the parallell *D D*, giueth me *B F*, and the parallell *E E*, giueth me *B G*, and now the line *B C*, is diuided in *F* & *G*, as is the other line *A B*, in D and *E*, which is that wh



required.

If the line *AB*, were longer then one of the sides of the Ruler, then should I finde what proportion it hath to his parts *A* D, *A E*, and that knowne I may worke as before in the former proposition.

9 *Two numbers being giuen to finde a third in continuall proportion.*

FIrst reckon the two numbers giuen on both sides of the lines of *Lines* from the center, and marke the termes to which either of them extendeth, then take out a line resembling the second number againe, and to it open the *Sector* in the termes of the first number, for so keeping the *Sector* at this angle, the parallell distance betweene the termes of the second laterall number, being measured in the same Scale, from whence his parallell was taken, shall giue the third number proportionall.

Let the two numbers giuen be 18, 24, these being resembled in lines, the worke will be in a manner all one, with that in the sixt *Prop.* and so the third proportionall number will be found to to be 32.

10 *Three*

10. *Three numbers being giuen to finde a fourth in discontinuall proportion.*

THe solution of this proposition, is in a manner all one with that before in the seuenth *Prop.* onely there may be some difficulty in placing of the numbers. To avoyd this, we must remember that three number being giuen, the question is annexed but to one, and this must allwayes be placed in the third place, that which agrees with this third number in denomination, shalbe the first number, and that which remaineth the second number. This being considered, reckon the first, and third numbers, which are of the first denomination on both sides of the lines of *Lines* from the center, and marke the termes to which either of them extendeth, then take out a line resembling the second number, and to it open the *Sector* in the termes of the first number, for so keeping the *Sector* at this angle, the parallell distance betweene the termes of the third laterall number, being measured in the same Scale from whence his parallell was taken, shall giue the fourth number proportionall.

As if a question were proposed in this manner, 10 yards cost 8 ℓ, how many yards may we buy for 12 ℓ? heere the question is annexed to 12; and therefore it shall be the third number, and because 8 is of the same denomination, it shall be the first number, then 10 remaining, it must be the second number, so will they stand in this order, 8, 10, 12. These being resembled in lines, the worke will be in a manner the same, with that in the seuenth *Prop.* and the fourth proportionall number will be found to be 15. For as 8 are to 10, so 12 vnto 15.

And this holdeth in direct proportion, where, as the first number is to the second, so the third to the fourth. So that if the third number be greater then the first, the fourth will be greater then the second, or if the third number be lesse then the first, the fourth will be lesse then the second, but in *reciprocall* proportion, commonly called the *Back rule*,

where by how much the first number is greater then the third, so much the second will be lesse then the fourth, or by how much the first number is lesse then the third, so much the second will be greater then the fourth. The manner of working must be contrary, that is; the *Sector* is to be opened in the termes of the third number, and the parallell resembling the number required, is to be found betweene the termes of the first number, the rest may be obserued as before, as for example.

If twelue men would raise a frame in ten dayes, in how many dayes would eight men raise the same frame? Here, because the fewer men would require the longer time, though the numbers be 12, 10, 8; yet the fourth proportionall will be found to be 15.

So if 60 yards, of three quarters of a yard in bredth, would hang round about a roome, and it were required to know how many yards of halfe a yard in bredth, would serue for the same roome. The fourth proportionall would be found to be 90.

So if to make a foote superficiall, 12 inches in bredth doe require 12 inches in length, and the bredth being 16 inches, it were required to knowe the length. Here, because the more bredth, the lesse length, the fourth proportionall will be found to be 9.

So if to make a Solid foote, a base of 144 inches, require 12 inches in height, and a base giuen being 216 inches, it were required to knowe how many inches it shall haue in height. The fourth proportionall would be found to be 8.

This last proposition of finding a fourth proportionall number, may be wrought also by the lines of *Superficies*, and by the lines of *Solids*.

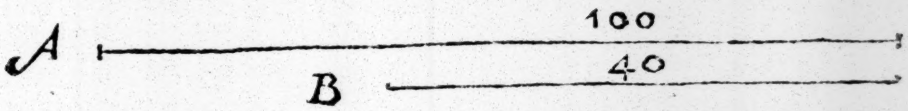
CHAP. III.

CHAP, III.

The vse of the lines of Superficies.

1 *To finde a proportion betweene two or more like* Superficies.

TAke one of the sides of the greater *Superficies* giuen, and according to it open the *Sector* in the points of 100 and 100, in the lines of *Superficies*, then take the like sides of the lesser *Superficies* seuerally, and carry them parallell to the former, till they stay in like points, so the number of points wherein they stay, shall shew their proportion vnto 100.



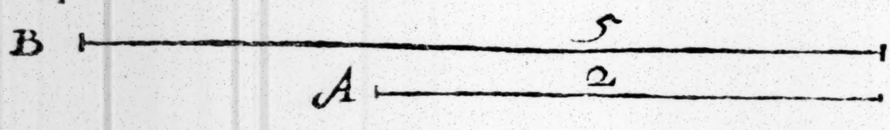
Let *A* and *B*, be the sides of like *Superficies*, as the sides of two squares, or the diameters of two circles, first I take the side *A*, and to it open the *Sector* in the points of 100, then keeping the *Seetor* to this angle, I enter the lesser side *B*, parallell to the former, and finde it to crosse the lines of *Superficies* in the points of 40, wherefore the proportion of the *Superficies*, whose side is *A*, to that whose side is *B*, is as 100 vnto 40, which is in lesser numbers, as 5 vnto 2.

This proposition might haue beene wrought by 60, or any other number that admits seuerall diuisions. It may also be wrought without opening the *Sector*, for if the sides of the *Superficies* giuen, be applied to the lines of *Superficies* beginning alwayes at the center of the *Sector*, there will be such proportion found betweene them, as betweene the number of parts whereon they fall.

2 *To*

2 *To augment a Superficies in a giuen Proportion.*
3 *To diminiſh a Superficies in a giuen Proportion.*

TAke the ſide of the *Superficies*, and to it open the *Sector* in the points of the numbers giuen; then keeping the *Sector* at that angle, the parallell diſtance between the points of the number required, ſhall giue the like ſide of the *Superficies* required.



Let *A* be the ſide of a Square to be augmented in the proportion of 2 to 5. Firſt I take the ſide *A*, and put it ouer in the lines of *Superficies*, in 2 and 2; ſo the parallel between 5 and 5, doth giue me the ſide *B*, on which if I ſhould make a Square, it would haue ſuch proportion to the ſquare of *A*, as 5 vnto 2.

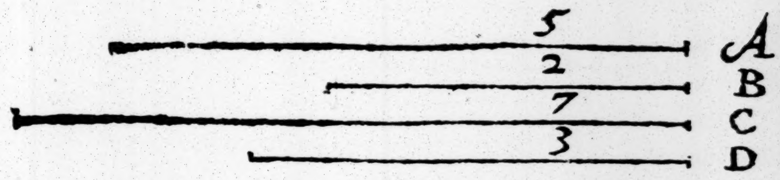
In like maner if *B* were the ſemidiameter of a circle to be diminiſhed in the proportion of 5 vnto 2, I would take out *B*, and put it ouer in the lines of *Superficies*, in 5 and 5; ſo the parallell betweene 2 and 2, would giue me *A*; on which Semidiameter if I ſhould make a circle, it would be leſſe then the circle made vpon the Semidiameter *B*, in ſuch proportion as 2 is leſſe then 5.

For varietie of worke the like caution may be here obſerued to that which we gaue in the third *Prop.* of *Lines.*

4 *To adde one like Superficies to another.*
5 *To ſubtract one like Superficies from another.*

FIrſt, the proportion betweene like ſides of the *Superficies* giuen, is to be found by the firſt *Prop.* of *Superficies*, then adde or ſubtract the numbers of thoſe proportions, and accordingly augment or diminiſh by the former *Prop.*

As

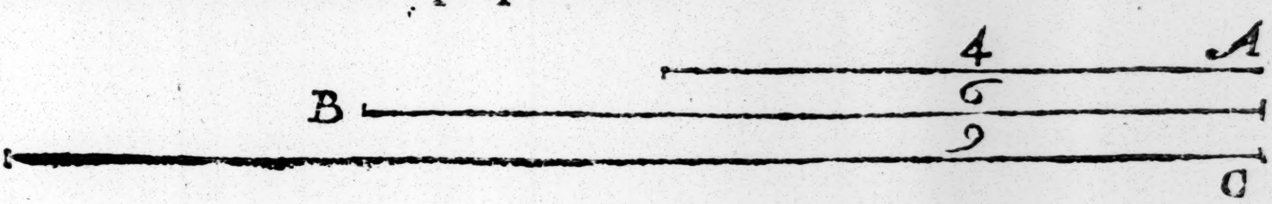


As if *A* and *B* were the ſide of two Squares, and it were required to make a third Square equall to them both. Firſt the proportion betweene the ſquares of *A* and *B*, would be found to be as 100 vnto 40, or in the leſſer numbers as 5 to 2; then becauſe 5 and 2 added do make 7, I augment the ſide *A* in the proportion of 5 to 7, and produce the ſide *C*, on which if I make a ſquare, it will be equall to both the ſquares of *A* and *B*, which was required.

In like maner *A* and *B* being the ſides of two Squares, if it were required to ſubtract the ſquare of *B* out of the ſquare of *A*, and to make a ſquare equall to the remainder, here the proportion being as 5 to 2, becauſe 2 taken out of 5, the remainder is 3, I would diminiſh the ſide *A* in the proportion of 5 to 3, and ſo I ſhould produce the ſide *D*, on which if I make a ſquare, it will be equall to the remainder when the ſquare of *B* is taken out of the ſquare of *A*, that is, the two ſquares made vpon *B* and *D*, ſhall be equall to the firſt ſquare made vpon the ſide *A*.

4 *To find a meane proportionall betweene two lines giuen.*

FIrſt find what proportion is betweene the lines giuen, as they are lines, by the fifth *Prop.* of *Lines*, then open the *Sector* in the lines of *Superficies*, according to his number, to the quantitie of the one, and a parallell taken betweene the points of the number belonging to the other line ſhall be the meane proportionall.



Let the lines giuen be *A* and *C*. The proportion between them as they are lines wil be found by the fifth *Prop.* of *Lines* to be as 4 to 9. Wherefore I take the line C, and put it ouer in the lines of *Superficies* betweene 9 and 9, and keeping the *Sector* at this angle, his parallell betweene 4 and 4 doth giue me *B* for the meane proportionall. Then for proofe of the operation I may take this line B, and put it ouer between 9 and 9: so his parallel between 4 and 4, shall giue me the first line A. Whereby it is plaine that these three lines do hold in continuall proportion; and therefore B is a meane proportionall betweene A and C the extremes giuen.

Vpon the finding out of this meane proportion depend many Corollaries, as

To make a Square equall to a Superficies giuen.

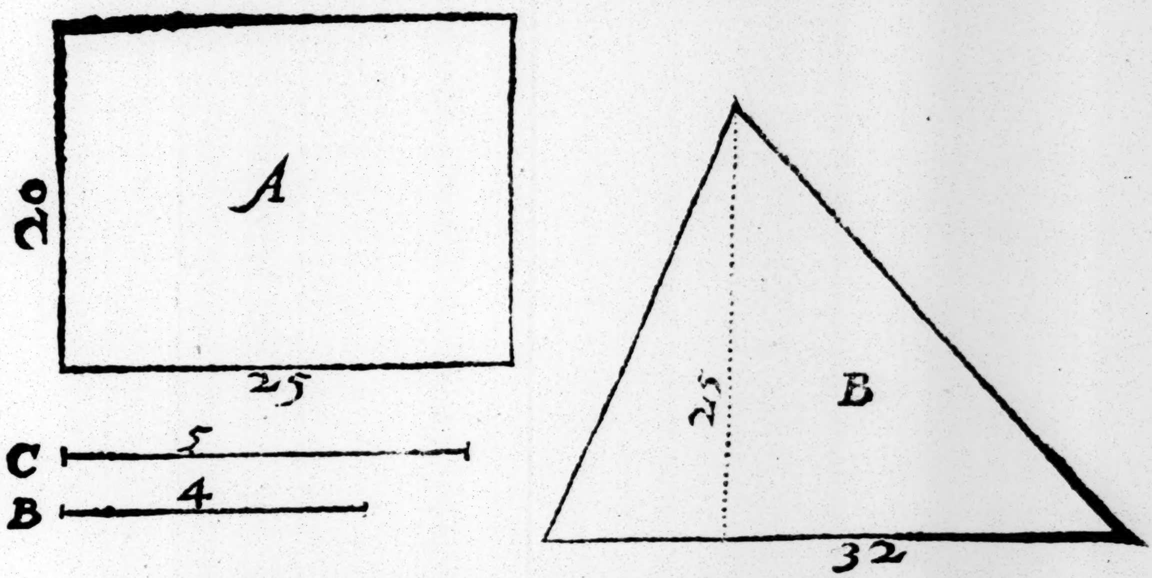
IF the *Superficies* giuen be a rectangle parallellogram, a meane proportionall betweene the two vnequal sides shall be the side of his equall square.

If it shall be a triangle, a meane proportion betweene the perpendicular and halfe the base shal be the side of his equal square. If it shall be any other right-lined figure, it may be resolued into triangles, and so a side of a square found equall to euery triangle; and these being reduced into one equall square, it shall be equall to the whole right-lined figure giuen.

To finde a proportion betweene Superficies, though they be vnlike one to the other.

IF to euery *Superficies* we find the side of his equall square, the proportion betweene these squares, shall be the proportion betweene the *Superficies* giuen.

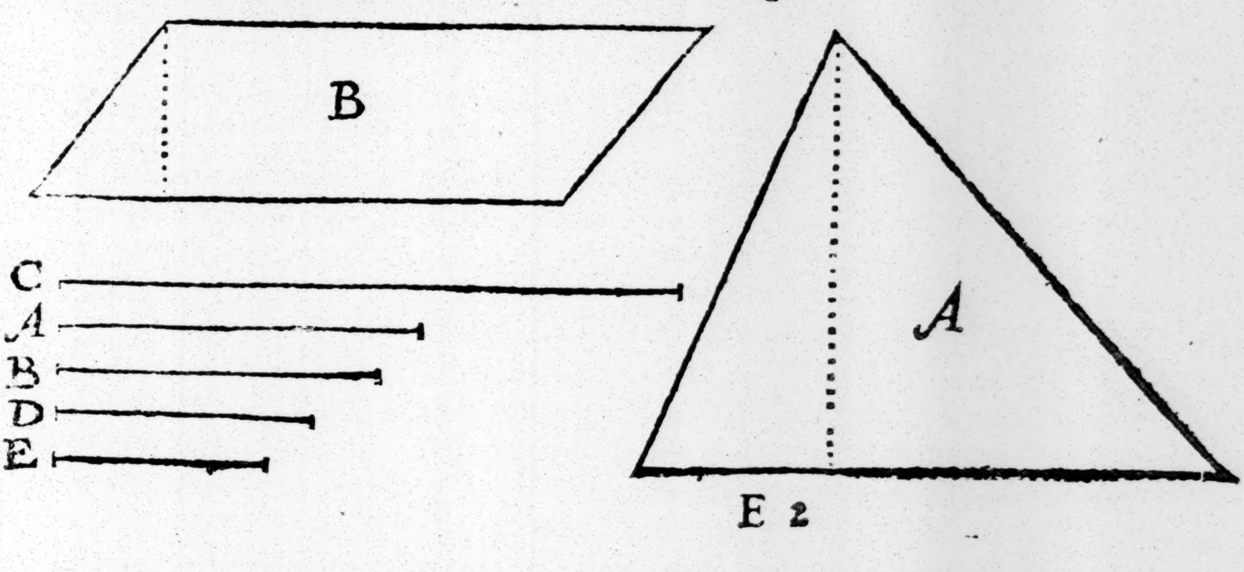
Let



Let the *Superficies* giuen, be the oblonge *A*, and the triangle *B*. First between the vnequall sides of *A*, I find a meane proportionall, and note it in *C*: this is the side of a square equall vnto *A*. Then betweene the prependicular of B, and halfe his base, I finde a meane proportionall, and note it in B: this is the side of a Square equall to *B*: but the proportion between the squares of *C* and B, will be found by the first *Prop.* of *Superficies* to be as 5 to 4: and therefore this is the proportion betwene those giuen *Superficies*.

To make a Superficies like to one Superficies and equall to another.

LEt the one *Superficies* giuen be the *triangle* A, and the other the *Rhomboides* B; and let it be required to make an-



other *Rhomboides* like to B,and equall to the *triangle* A.

First betwveen the perpendicular and the baſe of *B*, I find a meane proportionall, and note it in *B*, as the ſide of his equall ſquare: then betweene the perpendicular of the triangle *A*,and halfe his baſe, I find a meane proportionall,and note it in *A*, as the ſide of his equall ſquare. Wherefore now as the ſide *B* is to the ſide *A*, ſo ſhall the ſides of the Rhomboides giuen be to *C* and *D*, the ſides of the Romboides required,& his pendicular alſo to *E*,the perpēdicular required.

Hauing the ſides and the perpendicular, I may frame the *Rhomboides* vp, and it will be equall to the triangle *A*.

If the *Superficies* giuen had been any other right-lined figures, they might haue been reſolued into triangles, and then brought into ſquares as before.

Many ſuch Corollaries might haue been annexed,but the meanes of finding a meane proportionall being knowne, they all follow of themſelues.

7 *To finde a meane proportionall betweene two numbers giuen.*

FIrſt reckon the two numbers giuen on both ſides of the Lines of *Superficies*,from the center, and mark the termes whereunto they extend; then take a line out of the Line of *Lines*, or any other ſcale of equall parts reſembling one of thoſe numbers giuen, and put it ouer in the termes of his like number in the lines of *Superficies*; for ſo keeping the *Sector* at this angle, the parallell taken from the termes of the other number and meaſured in the ſame ſcale from which the other parallell was taken, ſhall here ſhew the meane proportionall which was required.

Let the numbers giuen be 4 and 9. If I ſhall take the line *A*, in the *Diagram* of the ſixt *Prop.* reſembling 4 in a ſcale of equall parts, and to it open the *Sector* in the termes of 4 and 4, in the lines of *Superficies*, his parallell betweene 9 and 9 doth giue me *B* for the meane proportionall. And this meaſured in the ſcale of equall parts doth extend to 6,

which

which is the meane proportionall number between 4 and 9. For as 4 to 6, so 6 to 9.

In like maner if I take the line *C*, resembling 9 in a scale of equall parts, and to it open the *Sector* in the termes of 9 and 9, in the lines of *Superficies*, his parallell between 4 and 4 doth giue me the same line *B*, which will proue to be 6, as before, if it be measured in the same scale whence *D* was taken.

8 *To find the square roote of a number.*
9 *The roote being giuen to find the square number of that roote.*

IN the extraction of a square roote it is vsuall to set pricks vnder the first figure, the third, the fifth, the seuenth, and so forward, beginning from the right hand toward the left, and as many pricks as fall to be vnder the square number giuen, so many figures shall be in the roote: so that if the number giuen be lesse then 100, the roote shall be only of one figure; if lesse then 10000, it shall be but two figures; if lesse then 1000000, it shall be three figures, &c.

Thereupon the lines of *Superficies* are diuided first into an hundred parts, and if the number giuen be greater then 100, the first diuision (which before did signifie only one) must signifie 100, and the whole line shall be 10000 parts: if yet the number giuen be greater then 10000, the first diuision must now signifie 10000, and the whole line be esteemed at 1000000 parts: and if this be too little to expresse the number giuen, as oft as we haue recourse to the beginning, the whole line shall increase it selfe an hundred times.

By this meanes if the last pricke to the left hand shall fall vnder the last figure, which will be as oft as there be odde figures, the number giuen shall fall out betweene the center of the *Sector* and the tenth diuision: but if the last prick shall fall vnder the last figure but one, which will be as oft as there be euen figures, then the number giuen shall fall out betweene the tenth diuision and the end of the *Sector*.

This being considered, when a number is giuen and the square roote is required, take a paire of compasses and setting one foote in the center, extend the other to the terme of the number giuen in one of the lines of *Superficies*; for this distance applied to one of the Lines of *Lines*, shall shew what the Square roote is, without opening the *Sector*.

Thus 64 doth giue a roote of 8, and 860 a roote of almost 19, and 1296 a roote of 36, and 7056 a roote of 84, and 62500 a roote of 250, and 714000 a roote of about 845, and so in the rest.

On the contrary, a number giuen may be squared, if first we extend the compasses to the number giuen in the lines of *Lines*, and then apply the distance to the *Lines* of *Superficies*, as may appeare by the former examples.

10 *Three numbers being giuen to find the fourth in a duplicated proportion.*

IT is plaine by the 19 and 20 *Prop.6.Lib.*of *Euclid*, that like *Superficies* do hold in a duplicated proportion of their homologall sides, whereupon a qnestion being moued concerning *Superficies* and their sides. It is vsuall in Arithmeticke that the proportion be first duplicated before the question be resolued, which is not necessarie in the vse of the *Sector*, only the numbers which do signifie *Superficies* must be reckoned in the lines of *Superficies*, and they which signifie the sides of *Superficies*, in the lines of *Lines*, after this maner.

If a question be made concerning a *Superficies*, the two numbers of the first denomination must be reckoned in the lines of *Lines*, and the *Sector* opened in the termes of the first number to the quantitie of a line out of the scale of *Superficies* resembling the second number; so his parallels taken betweene the termes of the third number, being measured in the same scale of *Superficies*, shall giue the Superficiall number which was required.

As if a Square, whose side is fortie perches in length, shall

containe ten acres in the *Superficies*, and it be required to know how many acres the Square should contain, whose side is sixtie perches.

Here if I tooke 10 out of the line of *Superficies*, and put it ouer in 40 in the lines of *Lines*, his parallell between 60 and 60 measured in the line of *Superficies*, would be $22\frac{1}{2}$; and such is the number of acres required. For Squares do hold in a duplicated proportion of their sides; wherefore when the proportion of their sides is as 4 to 6, and 4 multiplied into 4 become 16, and 6 multiplied into 6 become 36, the proportion of their squares shall be as 16 to 36; and such is the proportion of 10 to $22\frac{1}{2}$.

If a field measured with a statute perch of $16\frac{1}{2}$ foote, shall containe 288 acres, and it be required to know how many acres it would containe if it were measured with a woodland perch of 18 foote.

Here because the proportion is reciprocall, if I tooke 288 out of the line of *Superficies*, and put it ouer in 18, in the lines of *Lines*, his parallell betweene $16\frac{1}{2}$ and $16\frac{1}{2}$ measured in the line of *Superficies*, would be 242; and such is the number of acres required.

For seeing the proportion of the sides is as 16 to 18, or in lesser numbers as 11 to 12, and that 11 multiplied into 11 become 121, and 12 into 12 become 144, the proportion of these *Superficies* shall be as a 121 to 144, and so haue 288 to 242, in *reciprocall* proportion.

On the contrary, if a question be proposed concerning the side of a *Superficies*, the two numbers of the first denomination must be reckoned in the lines of *Superficies*, and the *Sector* opened in the termes of the first number, to the quantitie of a line, out of the line of *Lines*, or some Scale of equall parts, resembling the second number; so his parallell taken between the termes of the third number being measured in the same scale with the second number, shal giue the fourth number required.

As if a field contained 288 acres when it was measured with a statute perch of $16\frac{1}{2}$, and being measured with another

ther perch, was found to containe 242 acres, it were required to know what was the length of the perch with which it was so measured.

Here because the proportion is reciprocall, if I tooke $16\frac{1}{2}$ out of the line of *Lines*, and put it ouer in 242 in the lines of *Superficies*, his parallell betweene 288 and 288, being measured in the line of *Lines*, would be 18, and such is the length of the perch in foote whereby the field was last measured.

For seeing the proportion of the acres is as 288 vnto 242, or in the least numbers as 144 to 121, and that the roote of 144 is 12, and the root of 121 is 11, the proportion of roots and consequently of the perches shall be as 12 to 11, and so are $16\frac{1}{2}$ to 18, in *reciprocall* proportion.

If 360 men were to be set in forme of a long square, whose sides shall haue the proportion of 5 to 8; and it were required to know the number of men to be placed in front and file: if the sides were onely 5 and 8, there should be but 40 men; but there are 360: therefore working as before, I find that

As 40 to the square of 5,
so 360 to the square of 15.

As 40 to the square of 8,
so 360 to the square of 24.

and so 15 and 24 are the sides required.

If 1000 men were lodged in a square ground, whose side were 60 paces, and it were required to know the side of the square wherein 5000 might be so lodged, here working as before, I should find that

As 1000 are to the square of 60:
so 5000 to the square of 134.

And such very neare is the number of paces required.

CHAP.

CHAP. IV.

The vſe of the lines of Solids.

To finde a proportion betweene two or more like Solids.

IN the Sphere, in regular, parallell, and other like bodies, whoſe ſides next the equall angles are proportionall, the worke is in a manner the ſame, with that in the firſt *Prop.* of *Superficies*, but that it is wrought on other lines.

Take one of the ſides of the greater *Solid*, & according to it open the *Sector* in the points of 1000 and 1000, in the lines of *Solids*, then take the like ſides of the leſſer *Solids* ſeuerally, and carry them parallell to the former, till they ſtay in like points, ſo the number of points wherein they ſtay, ſhall ſhew their proportion to 1000.

Let *A* and *B*, be the like ſides of like Solids, either the diameters, or ſemidiameters of two ſpheres, or the ſides of two cubes, or other like. Firſt I take the ſide *A*, and to it open the *Sector* in the points of 1000, then keeping the *Sector* at this angle, I enter the leſſer ſide B, parallell to the former, and finde it to croſſe the line of *Solids* in the points of 400, and ſuch is the proportion betweene the Solids required, which in leſſer number is as 5 to 2.

This propoſition might haue beene wrought by 60, or any other number that admits ſeuerall diuiſions.

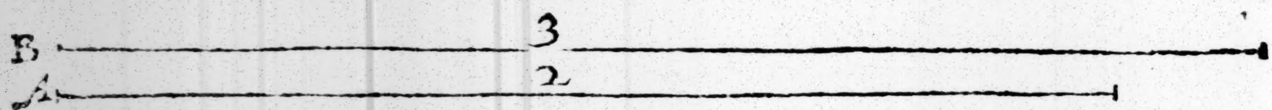
It may alſo be wrought without opening the *Sector*, for if the ſides of the Solids giuen, be applied to the lines of *Solids*, begining allwayes at the center of the *Sector*, there will be ſuch proportion betweene them, as betweene the numbers of parts whereon they fall.

2 ***To augment a Solid in a giuen proportion.***

3 ***To diminiſh a Solid in a giuen proportion.***

TAke the ſide of the Solid giuen, and to it open the *Sector*, in the points of the number giuen: then keeping the Sector at that angle, the parallell diſtance betweene the points of the number required, ſhall giue the like ſide of the Solid required.

If it be a ***paralleleopipedon***, or ſome irregular Solid, the other like ſides may be found out in the ſame manner, and with them the Solids required, may be made vp with the ſame angles.



Let *A* be the ſide of a cube, to be augmented in the proportion of 2 to 3. Firſt I take the ſide *A*, and put it ouer in the lines of *Solids* in 2 and 2, ſo the parallell betweene 3 and 3, doth giue me the ſide B, on which if I make a cube, it will haue ſuch proportion to the cube of *A*, as 3 to 2.

In like manner, if B were the diameter of a Sphere, to be diminiſhed in the proportion of 3 to 2. I would take out B, and put it ouer in the lines of *Solids*, in 3 and 3, ſo the parallell betweene 2 and 2, would giue me *A*: to which diameter if I ſhould make a Sphere, it would be leſſe then the Sphere, whoſe diameter is B, in ſuch proportion as 2 is leſſe then 3.

Here alſo for variety of worke, may the like caution be obſerued to that which we gaue in the third *Prop.* of *Lines*.

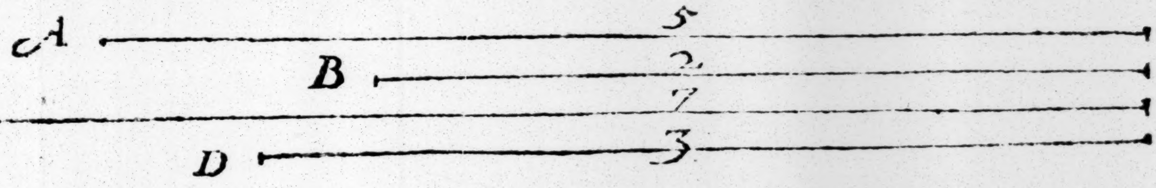
4 ***To adde one like Solid to another.***

5 ***To ſubtract one like Solid from another.***

FIrſt the proportion betweene the ſides of the like Solids giuen, is to be found by the firſt *Prop.* of *Solids*: then adde

or

or ſubtract thoſe proportions, and accordingly augment or diminiſh by the former *Prop.*



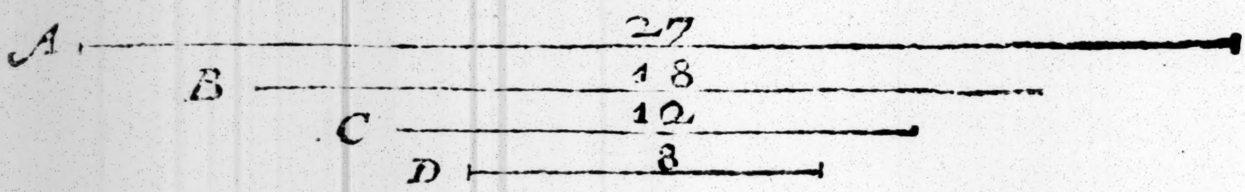
As if *A* and *B* were the ſides of two cubes, and it were required to make a third cube equall to them both : firſt the proportion betweene the ſides *A* and *B*, would be found to be as 100 to 40, or in leſſer termes as 5 to 2. Then becauſe 5 and 2 being added do make 7, I augment the ſide *A* in the proportion of 5 to 7, and produce the ſide *C*, on which if I make a cube, it will be equall to both the cubes of *A* and *B*, which was required.

In like maner *A* and *B* being the fides of two cubes, if it were required to ſubtract the cube of B out of the cube of A, and to make a cube equal to the remainder. Here the proportion being as 5 to 2, becauſe 2 taken out of 5, the remainder is 3, I ſhould diminiſh the ſide A in the proportion of 5 to 3, and ſo I ſhould haue the ſide D, on which if I make a cube, it will be equall to the remainder when the cube of B is taken out of the cube of A, that is the two cubes made vpon B and D, ſhall be equall to the firſt cube made vpon the ſide A.

6 *To find two meane proportionall lines betweene two extreme lines giuen.*

FIrſt I find what proportion is betweene the two extreme lines giuen as they are lines, by the fifth *Prop.* of *Lines*, then open the *Sector* in the lines of *Solids*, to the quantitie of the former extreme, and a parallell betweene the points of the number belonging to the other extreme, ſhall be that meane proportionall which is next the former extreme. This done, open the *Sector* againe to this meane proportionall in the points of the former extreme, and the parallell diſtance

betweene the points of the latter extreme, shall be the other meane proportionall required.



Let the two extreme lines giuen be A and D, the proportion betweene them, as they are lines, will be found to be as 27 to 8. Wherefore I take the line A, and put it ouer in the lines of *Solids* betweene 27 and 27, and keeping the *Sector* at this angle, his parallell betweene 8 and 8, doth giue me B, the meane proportionall next vnto A. Then put I ouer this line B, betweene the aforesaid 27 and 27, and his parallell betweene 8 and 8 doth giue me the line C, the other meane proportionall which was required.

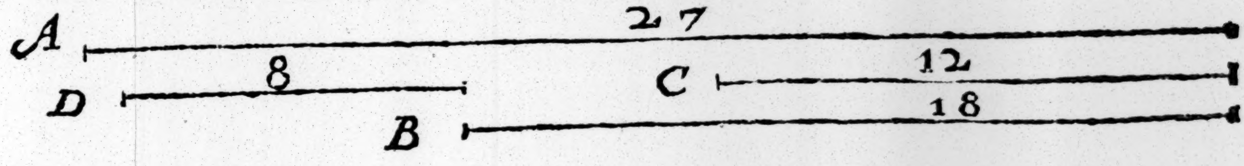
Againe, for proofe of the operation I put ouer this line C in the aforesaid 27 and 27, and his parallell between 8 and 8 doth giue me the very line D: whereby it is plaine that these foure lines do hold in continuall proportion; and so B and C are found to be the meane proportionals betweene A and D the extremes giuen.

7 *To find two meane proportionall numbers between two extreme numbers giuen.*

First reckon the numbers giuen on both sides of the lines of *Solids*, beginning from the center, and marking the termes whereto they extend: then take a line out of the line of *Lines*, or any other scale of equall parts resembling the former of those numbers, and put it ouer in the lines of *Solids*, betweene the points of his like number, and a parallell betweene the points belonging to the other extreme, measured in the scale from whence the other parallell was taken, shall giue that meane proportionall number which is next the former extreme. This done, open the *Sector* againe to this meane proportionall in the points of the former extreame,

and

and the parallell diſtance betweene the points of the latter extreame, meaſured in the ſame ſcale as before, ſhall there ſhew the other meane proportionall required.



Let the two extreame numbers giuen be 27 and 8; if I ſhall take the line A, reſembling 27 in a ſcale of eqnall parts, and to it open the *Sector* in 27 and 27, in the line of *Solids*, his parallell betweene 8 and 8 doth giue me B for his next meane proportionall, and this meaſured in the former ſcale doth extend to 18. Then put I ouer this line B between the aforeſaid 27 and 27, and his parallell between 8 and 8 doth giue me C for the other meane proportionall, and this meaſured in the former ſcale doth extend to 12. Againe, for proofe of my worke, I put ouer this line C betweene 27 and 27, as before, and his parallell betweene 8 and 8 doth giue me D, which meaſured in the former ſcale doth extend to 8, which was the latter extreame number giuen; whereby it is plaine that theſe foure numbers do hold in continuall proportion: and therefore 18 and 12 are meane proportionals betweene 27 and 8, which was required.

8 *To finde the cubique roote of a number.*

9 *The roote being giuen to finde the cube number of that roote.*

IN the extraction of a cubique root, it is vſuall to ſet pricks vnder the firſt figure, the fourth, the ſeuenth, the tenth, and ſo forward, omitting two, and pricking the third from the righthand toward the left; and as many pricks as fall to be vnder the cubique number, ſo many figures ſhall be in the roote. So that if the number giuen be leſſe then 1000, the roote ſhall be only of one figure; if leſſe then 1000000, it ſhall be but of two figures; if aboue theſe, and leſſe then 1000000000, it ſhall be but three figures; &c. whereupon

the lines of *Solids* are diuided, first into 1000 parts, and if the numbers giuen be greater thē 1000, the first diuision (whcih before did signifie onely one) must signifie 1000, and the whole line shall be 1000000 : if yet the number giuen be greater then 1000000, the first diuision must now signifie 1000000, and the whole line be esteemed at 1000000000 parts, and if these be to little to expresse the numbers giuen, as oft as wee haue recourse to the begining, the whole line shall encrease it selfe a thousand times.

By these meanes, if the last pricke, to the left hand, shall fall vnder the last figure, the number giuen shall be reckoned at the beginning of the lines of *Solids*, from 1 to 10, and the first figure of the roote shall be alwayes either 1, or 2. If the last pricke shall fall vnder the last figure but one, then the number giuen shall be reckoned in the middle of the line of *Solids*, betweene 10 and 100, and the first figure of the roote shall be alwayes either 2, or 3, or 4. But if the last pricke shall fall vnder the last figure but two, then the number giuen, shall be reckoned at the end of the line of Solids, betweene 100, and 1000.

This being considered when a number is giuen, and the cubique roote required : Set one foote of the compasses in the center of the *Sector*, extend the other in the line of *Solids*, to the points of the number giuen : for this distance applied to one of the line of *Lines*, shall shew what the cubique roote is, without opening the *Sector*.

So the nearest roote of 8490000, is about 204.
The nearest roote of 84900000, is about 439.
The nearest roote of 849000000, is about 947.

On the contrary, a number may be cubed, if first we extend the compasses to the number giuen, in the line of *Lines*, and then apply the distance to the lines of *Solids* ; as may appeare by the former examples.

10 *Three numbers being giuen to finde a fourth in a triplicated proportion.*

AS like *Superficies* do hold in a duplicated proportion, so like solids in a triplicated proportion of their homologall sides: and therefore the same worke is to be obserued here on the lines of *Solids*, as before in the lines of *Superficies*; as may appeare by these two examples.

If a cube whose side is 4 inches, shall be 7 pound weight, and it be required to know the weight of a cube whose side is 7 inches; here the proportion would be,

As 4 are to a cube of 7:
so 7 to a cube of 37 $\frac{1}{2}$.

And if I tooke 7 out of the lines of *Solids*, and put it ouer in 4 and 4, in the lines of *Lines*, his parallell between 7 and 7 measured in the lines of *Solids*, would be 37 $\frac{1}{2}$; and such is the weight required.

If a bullet of 27 pound weight haue a diameter of 6 inches, and it be required to know the diameter of the like bullet, whose weight is 125 pounds; here the proportion would be,

As the cubique root of 27 is vnto 6:
so the cubique root of 125 is vnto 10.

And if I tooke 6 out of the line of *Lines*, and put it ouer in 27 and 27 of the lines of *Solids*, his parallell betweene 125 and 125 measured in the line of *Lines*, would be 10; and such is the length of the diameter required.

The end of the first booke.

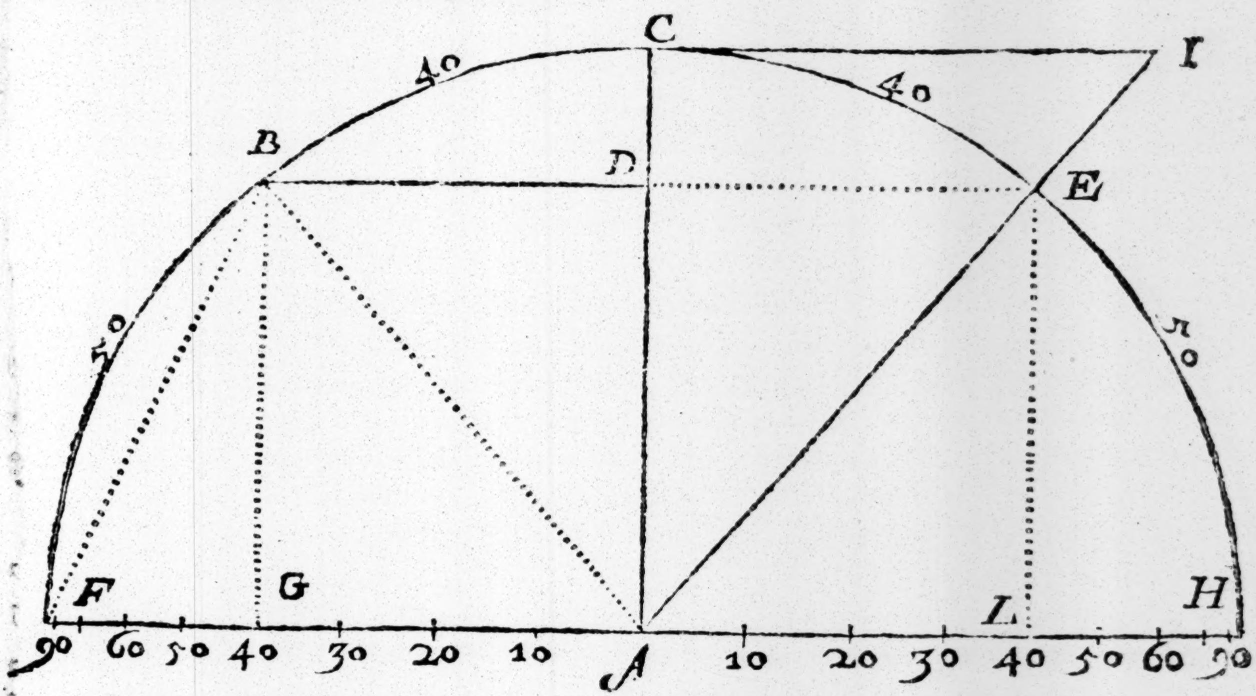
THE SECOND BOOKE OF THE *SECTOR*,

Containing the vse of the Circular *Lines*.

CHAP. I.

Of the nature of Sines, Chords, Tangents *and* Secants, *fit to be knowne before hand in reference to right-line Triangles.*

IN the *Canon* of *Triangles*, a circle is commonly diuided into 360 *degrees*, each *degree* into 60 *minutes*, each *minute* into 60 *seconds*.



A semicircle therefore is an arke of 180 gr.

G A

A quadrant is an arke of 90 *gr.*

The measure of an angle is the arke of a circle, described out of the angular point, intercepted betweene the sides sufficiently produced.

So the measure of a right angle is alwayes an arke of 90 *gr.* and in this example the measure of the angle *B A D* is the arke *B C* of 40 *gr*; the measure of the angle *B A G*, is the arke *B F* of 50 *gr.*

The complement of an arke or of an angle doth commōly signifie that arke which the giuen arke doth want of 90 *gr*: and so the arke *B F* is the cōplement of the arke *B C*; & the angle *B A F*, whose measure is *B F*, is the complement of the angle *B A C*; and on the contrary.

The complement of an arke or angle in regard of a semicircle, is that arke which the giuen arke wanteth to make vp 180 *gr*: and so the angle *E A H* is the complement of the angle *E A F*, as the arke *E H* is the complement of the arke *F E*, in which the arke *C E* is the excesse aboue the quadrant.

The proportions which these arkes (being the measures of angles) haue to the sides of a triangle, cannot be certaine, vnlesse that which is crooked be brought to a straight line; and that may be done by the application of *Chords*, *Right Sines*, *versed Sines*, *Tangents* and *Secants*, to the semidiameter of a circle.

A *Chorde* is a right line subtending an arke: so *B E* is the chorde of the arke *B C E*, and *B F* a chorde of the arke *B F.*

A *right Sine* is halfe the chorde of the double arke, viz. the right line which falleth perpendicularly from the one extreme of the giuen arke, vpon the diameter drawne to the other extreme of the said arke.

So if the giuen arke be *B C*, or the giuen angle be *B A C*, let the diameter be drawne through the center *A* vnto *C*; and a perpendicular *B D* be let downe from the extreme *B*, vpon *A C*; this perpendicular *B D* shall be the *right sine* both of the arke *B C*, and also of the angle *B A C*: and it is also

also the halfe of the chord B E, subtending the arke B C E, which is double to the giuen arke B C. In like maner, the semidiameter F A, is the *right sine* of the arke F C, and of the right angle F A C; for it falleth perpendicularly vpon A C, and it is the halfe of the chord F H.

This whole Sine of *90 gr.* is hereafter called *Radius*; but the other *Sines* take their denomination from the degrees and minutes of their arks.

Sinus versus, the *versed sine* is a segment of the diameter, intercepted betweene the *right sine* of the same arke, and the circumference of the circle. So D C is the *versed sine* of the arke C B, and G F the *versed sine* of the arke B F, and G H the *versed sine* of the arke B H.

A *Tangent* is a right line perpendicular to the diameter, drawne by the one extreme of the giuen arke, and terminated by the *secant* drawne from the center through the other extreme of the said arke.

A *Secant* is a right line drawne from the center, through one extreme of the giuen arke, till it meete with the *tangent* raised from the diameter at the other extreme of the said arke.

So if the giuen arke be C E, or the giuen angle be C A E, let the diameter be drawne through the center A to C, and in C to A C, be raised a perpendicular C I. Then let another line be drawne from the center A through E, till it meet with the perpendicular C I in I; the line C I is a *Tangent*, and A I is the *Secant* both of the arke C E, and of the angle C A E.

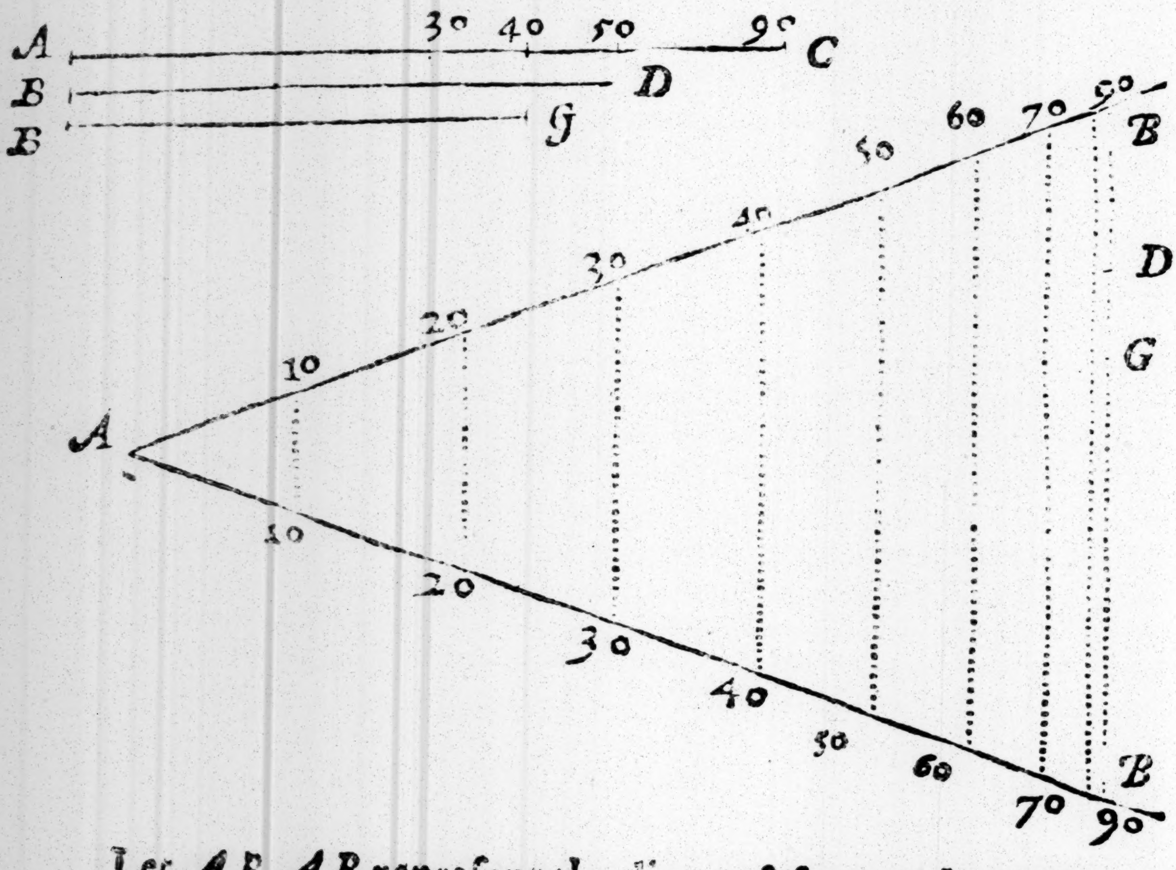
CHAP. II.

Of the generall vse of Sines *and* Tangents.

1 *The Radius being knowne to find the right sine of any arke or angle.*

IF the Radius of the circle giuen be equall to the laterall Radius, that is, to the whole line of *Sines* on the *Sector*, there needs no farther worke, but to take the other sines also out of the side of the *Sector*. But if it be either greater or lesser, then let it be made a parallell Radius, by applying it ouer in the lines of *Sines*, betweene 90 and 90; so the parallell taken from the like laterall sines, shall be the *sine* required.

As if the giuen Radius be *A C*, and it were required to find the sine of 50 *Gr.* & his complement agreeable to that radius.



Let *A B*, *A B* represent the lines of *sines* on the *Sector*, and let B B, the distance betweene 90 and 90, be equall to the giuen

giuen radius *A C*. Here the lines *A* 40, *A* 50, *A* 90, may be called the *laterall sines* of 40, 50, & 90; in regard of their place on the sides of the *Sector*. The lines betweene 40 and 40, betweene 50 and 50, betweene 90 and 90, may be called the *parallell sines* of 40, 50, and 90; in regard they are parallell one to the other. The whole sine of 90 *Gr.* here standing for the semidiameter of the circle, may be called the Radius. And therefore if *A C* be put ouer in the line of *Sines* in 90 and 90, and so made a *parallell radius*, his parallell sine betweene 50 and 50, shall be B D, the sine of 50 required. And because 50 taken out of 90, the complement is 40; his *parallell sine* betweene 40 and 40, shall be B G, the sine of the complement which was required.

2 *The right sine of any arke being giuen to finde the Radius.*

TVrne the sine giuen into a parallell sine, and his parallell *Radius* shall be the *Radius* required.

As if B D were the giuen sine of 50 *Gr.* and it were required to finde the Radius: let B D be made a parallell sine of 50 *Gr.* by applying it ouer in the lines of *Sines*, betweene 50 and 50; so his parallell Radius betweene 90 and 90 shall be A C, the Radius required.

3 *The Radius of a circle, or the right Sine of any arke being giuen, and a streight line resembling a Sine, to find the quantitie of that vnknowne* Sine.

LEt the Radius or right sine giuen be turned into his parallell; then take the right line giuen, and carrie it parallell to the former, till it stay in like *Sines*: so the number of degrees and minutes where it stayeth, shall giue the quantitie of the Sine required.

As if B D were the giuen sine of 50 *Gr.* and B G the streight line giuen: first I make BD a parallell sine of 50 *Gr*; then keeping the *Sector* at this angle, I carie the line B G

parallell, and find it to stay in no other but 40 and 40; and therefore 40 *gr.* is his quantitie required.

4 *The Radius or any right Sine being giuen, to finde the versed sine of any arke.*

If the arke, whose *versed sine* is required, be lesse then the quadrant, take the sine of the complement out of the radius, and the remainder shall be the *sinus versus*, the versed sine of that arke.

As if A B being the laterall *Radius*, it were required to find to find the versed sine of 40 *gr*; here the sine of the complement is A 50, and therefore B 50 is the *versed sine* required. Or if I reckon from B, at the end of the Sector, toward the center, the distance from 90 to 80, is the versed sine of 10 *gr*; from 90 to 70, the versed sine of 20 *gr*; from 90 to 60, is the versed sine of 30 *gr*; and so in the rest.

If A D be the giuen *sine* of 50 *gr.* and it be required to find the *versed sine* of 50 *gr*; here because A D is vnequall to the laterall sine of 50 *gr*, I make it a parallell. And first I find the radius A C; then the sine of the complement A 40, which being taken out of A C, leaueth C 40 for the versed sine of 50 *gr.* which was required.

But if the arke, whose versed sine is required, be greater then the quadrant, his versed sine also is greater then the *Radius*, by the right sine of his excesse aboue 90 *gr.*

As if A C being the Radius giuen, it were required to find the versed sine of 130 *gr:* here the excesse aboue 90 *gr.* is 40 *gr*; and therefore the versed sine required is equall to the Radius A C and A 40, both being set together.

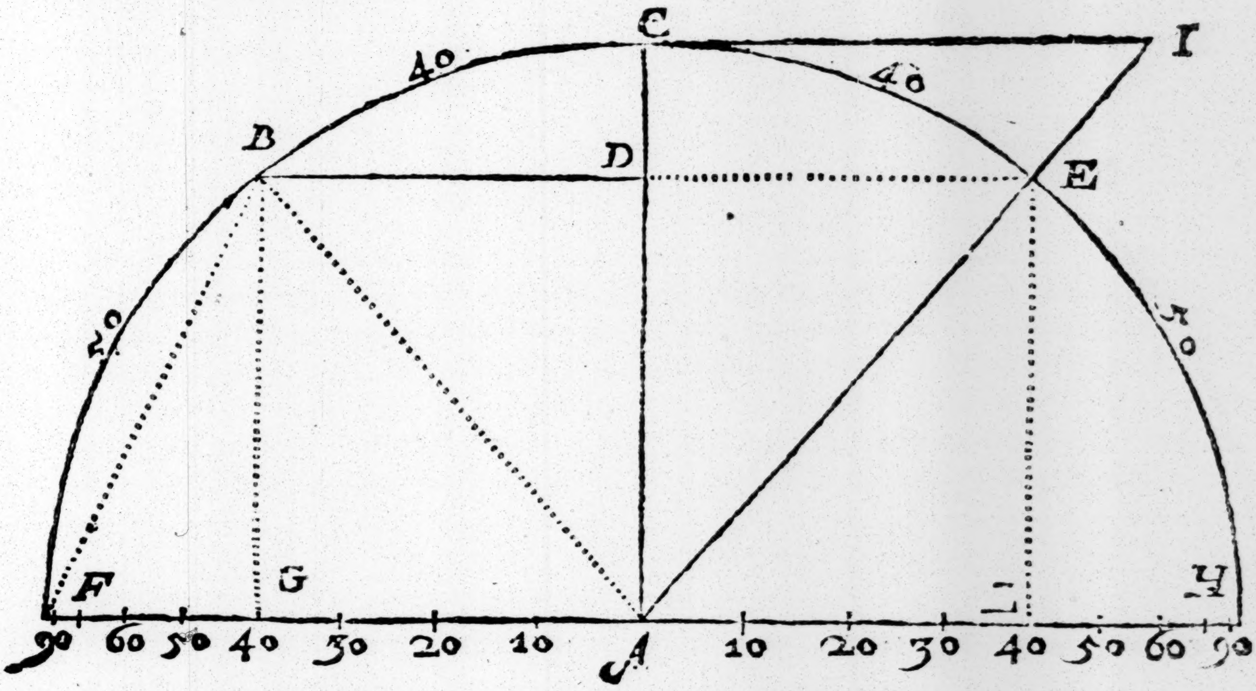
5 *The Diameter or* Radius *being giuen to finde the Chords of euery arke.*

The sines may be fitted many wayes to serue for chords.

1 A *sine* being the halfe of the *chord* of the double arke, if the *sine* be doubled, it giueth the *chord* of the double ark,

a *Sine* of 10 *gr.* doubled giueth a *Chord* of 20 *gr*; and a *Sine* of 15 *gr.* being doubled, giueth a *Chord* of 30 *gr*; and so in the rest. As here B D, the sine of B C, an arke of 40 *gr.* being doubled giueth B E the chord of B C E, which is an arke of 80 *gr.* Wherefore if the Radius of the circle giuen be equall to the laterall Radius, let the *Sector* be opened neare vnto his length, so that both the lines of *Sines* may make but one direct line: so the distance on the sines betweene 10 and 10, shall be a chord of 20; the distance betweene 20 and 20, shall be a chord of 40; and the distance betweene 30 and 30, shall be a chord of 60; and so in the rest.

2 Because a sine is the halfe of the chord of the double arke, the proportion holdeth.



As the diameter F H vnto the radius A H, so the chord B E vnto the sine D E, or the chord G L vnto the sine A L: and then if the radius A H, be put for the diameter, which is a chord of 180 gr, the sine D E or A L shall serue for a chord of 80 *gr*, and the semiradius which is the sine of 30 *gr*, shall serue for a chord of 60 *gr*, and go for the semidiameter of a circle, and so in the rest. So that by these meanes we shall not need to double the lines of *Sines* as before, but onely to double the numbers. And to this purpose I haue subdiuided

each

each degree of the ſines into two, that ſo they might ſhew how far the halfe degrees do reach in the ſines, and yet ſtand for whole degrees when they are vſed as chords.

Wherefore if the Radius of the circle giuen be equall to the lateral ſemiradius (the ſine of 30 *Gr.* and chord of 60 *Gr.*) there needs no farther work then to take the ſine of 10 *Gr.* for a chord of 20 *Gr.* and a ſine of 15 *Gr.* for a chord of 30 *Gr.* &c.

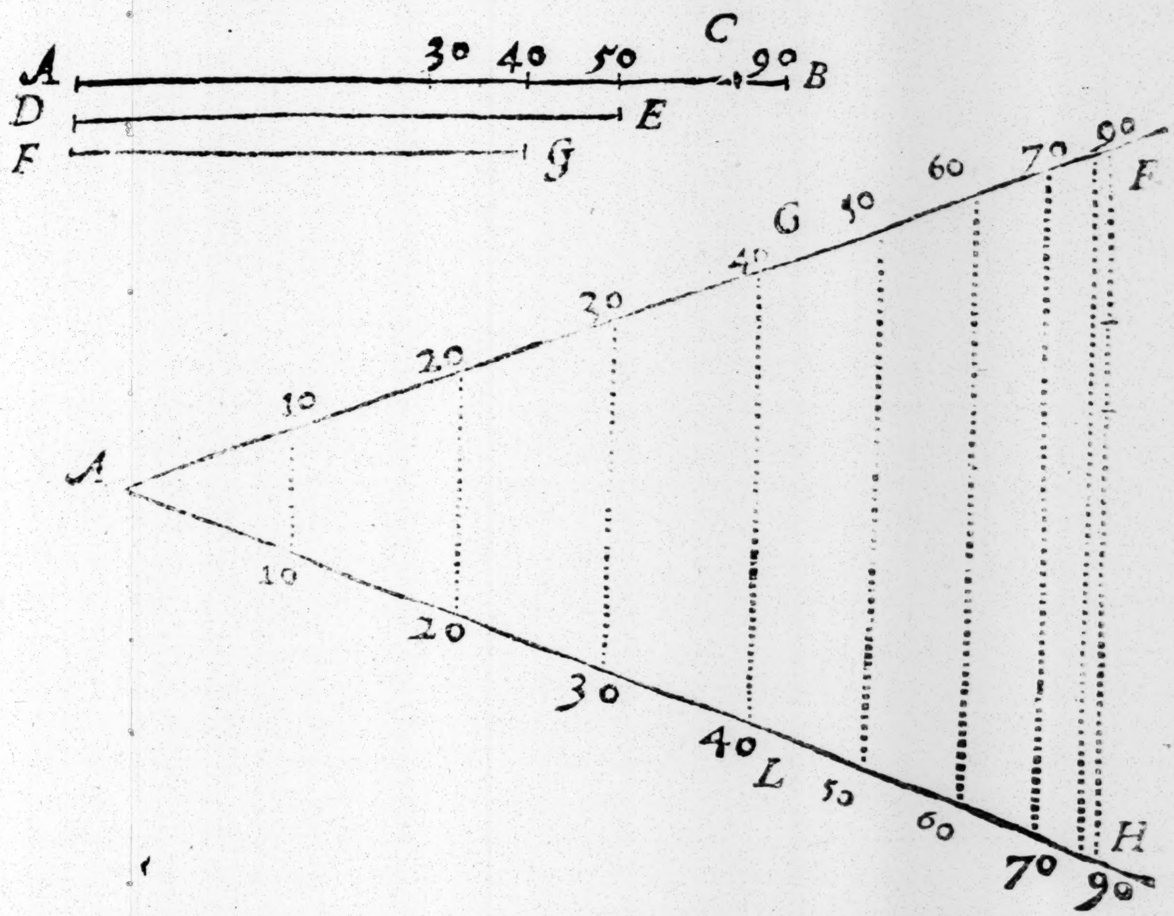
But if the Radius of the circle giuen be either greater or leſſer then the laterall ſemiradius, take the diameter of it, and make it a parallell chord of 180 *Gr.* by applying it ouer the lines of *Sines* between 90 and 90: or take the Radius or Semidiameter which is equall to the chord of 60 *Gr.* and make it a parallell Radius of 60 *Gr.* by applying it ouer in the ſines of 30 and 30, and keepe the Sector at this angle. The parallels taken from the laterall *chords* ſhall be the *chords* required.

As if the diameter of a circle giuen were the line *A B*, and it were required to find the chord of 80 gr: firſt, I make *A B* a parallell chord of 180 *Gr.* or the halfe of it a parallell chord of 60 *Gr*; ſo his parallell *L G* doth giue me *F G* the chord of 80 *Gr.* which was required.

3 Seeing that as the ſine of the complement of the halfe arke is vnto the *Radius*, ſo the ſine of the ſame whole arke is vnto the chord of it: if we ſeeke but for one ſingle chord, we may finde it without either doubling the ſines, or doubling the number. For applying ouer the Radius giuen in the ſine of the complement of halfe the arke required, his parallell ſine ſhall be the chord required.

As if the ſemidiameter of the circle giuen were *A C*, and it were required to find the chord of 40 *Gr*: the halfe of 40 *Gr.* is 20 *Gr.* the complement of 20 *Gr.* is 70 *Gr.* Wherefore I make *A C* a parallell ſine of 70 *Gr.* and his parallell ſine *G L* doth giue me *F G* the chord of 40 *Gr.* agreeable to the ſemidiameter *A C.*

6 Th



6 *The chord of any arke being giuen to find the diameter and* Radius.

TVrne the chord giuen vnto a parallell chord, and his parallell semiradius shall be the semidiameter, and the parallell radius shall be the diameter.

As if *F G* be the chord of 80 *gr.* I put this ouer in *G* and *L*, the sine of 40, and chord of 80 *gr.* and the parallell chord of 180 *gr.* giueth me *A B* the diameter required.

Or if I turne the chord giuen into a parallell sine of the same quantitie, his parallell sine of the complement of halfe the arke, doth giue me the semidiameter.

As if *F G* be the giuen chord of 40 *gr.* I put it ouer in *G* and *L*, the sines of 40 *gr*; then because the halfe of 40 *gr.* is 20 *gr.* and the complement of 20 *gr.* is 70 *gr.* I take out the parallell sine of 70 *gr.* and it giueth me *A C* for the semidiameter, agreeable to that chord of 40 *gr.*

7 *To open the Sector to the quantitie of any angle giuen.*

8 *The Sector being opened, to find the quantitie of the angle.*

IT is one thing to open the edges of the Sector to an angle, and another thing to open the lines on the Sector to the same angle. For the lines of *lines* on the one side, & the lines of *sines* on the other side, do make an angle of 2 *gr.* when the Sector is close shut, and the edges doe make no angle at all. So likewise the lines of *Superficies* and the lines of *Solids* doe make an angle of 10 *gr*, which are to be allowed to the edges.

The lines of *lines* may be opened to a right angle, if the whole line of 100 parts be applied ouer in 80 and 60.

The lines of *sines* may be opened to a right angle, if the large secant of 45 *gr.* be applied ouer in the sines of 90 *gr.* or if the sine of 90 *gr.* be applied ouer in the sines of 45 *gr.* or if the sine of 45 *gr.* be applied ouer in the sines of 30 *gr.*

If it be required to open those lines to any other angle, take out the chord thereof, and apply it ouer in the *semiradius*, and those lines shall be opened to that angle.

As if it were required to open the Sector in the lines of *sines* to an angle of 40 *gr*, take out the chord of 40 *gr*, and to it open the Sector in the chord of 60 *gr*; so shall the lines of *sines* be opened to the angle required. Or if the same chord of 40 *Gr.* be applied ouer betweene 50 and 50, in the lines of *lines*, they shall also be opened to the same angle. If it be applied ouer in 25 of the lines of *Superficies*, or 125 in the lines of *Solids*, they also shall be opened to the same angle: because the chord of 60 *Gr.* or sine of 30 *Gr.* and 50 in the lines of *lines*, and 25 in the lines of *Superficies*, and 125 in the *Solids*, are all of the same length with the semiradius.

Or if the *Semiradius* be applied ouer betweene the sine of 30 *Gr.* and the sine of the complement of the angle required, it will open the lines of *Sines* to that angle.

As

As if the semiradius be applied ouer in the sines of 30 *Gr.* and the sine of 50 *Gr.* it shall open the lines of *Sines* to an angle of 40 *Gr.*

On the contrary, if the *Sector* be opened to an angle, and it be required to know the quantitie thereof, open the compasses to the semiradius, and setting one foote in the sine of 30 *Gr*. turne the other toward the other line of *sines*, and it shall fall there in the complement of the angle; if it fall on 50 *Gr*. the angle is 40 *Gr*; if on 60 *Gr*. the angle is 30 *Gr.* &c.

Or take ouer the parallell chord of 60 *Gr.* and measure it in the laterall chord, and it shall there shew the quantitie of the angle. As if the *Sector* being opened to an angle, I should take ouer the parallell of 30 *Gr.* of the sines, and 60 *Gr.* of the chords, and measure it in the laterall chords, find it to be 40 *Gr*; the angle comprehended betweene the lines of *Sines* is 40 *Gr.* but the angle betweene the edges of the Sector is 2 *Gr.* lesse, and therefore but 38 *Gr.*

9 *To finde the quantitie of any angle giuen.*

IF out of the angular point, to the quantitie of the *Semiradius*, be described an occult arke that may cut both sides of the angle, the chord of this arke measured in the laterall chord, shall giue the quantitie of the angle.

Let the angle giuen be *B A C*: first I take the *Semiradius* with the compasses, and setting one foote in *A*, I cut the sides of the angle in *B* and *C*; then I take the chord *B C*, and measure it in the laterall chord, and I find it to be 11 *Gr.* and 15 *M.* and such is the quantitie of the angle giuen.

Or if the arke be described out of the angular point at any other distance, let the semidiameter be turned into a pa-

rallell chord of 60 *Gr.* then take the chord of this arke, and carrie it parallell till it crosse in like chords: so the place where it stayeth shall giue the quantitie of the angle.

As in the former example, if I make the semidiameter *A B* a parallell chord of 60 *Gr.* and then keeping the *Sector* at that angle, carrie the chord *B C* parallell, till it stay in like chords; I shall finde it to stay in no other but 11 *Gr.* 15 *M.* and such is the angle *B A C*.

10 Upon a right line and a point giuen in it, to make an angle equall to any angle giuen.

First out of the point giuen describe an arke, cutting the same line: then by the 5. *Prop* afore, find the chord of the angle giuen agreeable to the semidiameter, and inscribe it into this arke: so a right line drawne through the point giuen, and the end of this chord, shall be the side that makes vp the angle.

Let the right line giuen be *A B*, and the point giuen in it be *A*, and let the angle giuen be 11 *gr.* 15 *m.* Here I open the compasses to any semidiameter *A B*, (but as oft as I may conueniently to the laterall semiradius) and setting one foot in *A*, I describe an occult arke *B C*; then I seeke out the chord of 11 *gr.* 15 *m.* and taking it with the compasses, I set one foote in B, the other crosseth the arke in C, by which I draw the line *A C*, and it makes vp the angle required.

11 To diuide the circumference of a circle into any parts required.

If 360 the measure of the whole circumference be diuided by the number of parts required, the quotient giueth the chord, which being found will diuide the circumference.

So a chord of 120 *gr.* will diuide the circumference into 3 equall parts; a chord of 90 *gr.* into 4 parts; a chord of 72 *gr.* into 5 parts; a chord of 60 *gr.* into 6 parts; a chord of 51 *gr.* 26. into 7 parts; a chord of 45 *gr.* into 8 parts; a chord of 40 *gr.* into

into 9 parts; a chord of 36 *gr.* into 10 parts; a chord of 32 *gr.* 44 *m.* into 11 parts; a chord of 30 *gr.* into 12 parts.

In like maner if it be required to diuide the circumference of the circle, whoſe ſemidiameter is *A B*, into 32: firſt I take the ſemidiameter *A B*, and make it a parallell chord of 60 *gr*; then becauſe 360 *gr.* being diuided by 32, the quotient will be 11 *gr.* 15 *m.* I find the parallell chord of 11 *gr.* 15 *m.* and this will diuide the circumference into 32.

But here the parts being many, it were better to diuide it firſt into fewer, and after to come ouer it againe. As firſt to diuide the circumference into 4, and then each 4 parts into 8, or otherwiſe, as the parts may be diuided.

12 *To diuide a right line by extreme and meane proportion.*

THe line to be diuided by extreme and meane proportion, hath the ſame proportion to his greater ſegment, as in figures inſcribed in the ſame circle, the ſide of an *hexagon* a figure of ſix angles, hath to a ſide of a *decagon* a figure of ten angles: but the ſide of a *hexagon* is a chord of 60 *gr.* and the ſide of a *decagon* is a chord of 36 *gr.*

Let *A B* be the line to be diuided: if I make *A B* a parallell chord of 60 *gr.* and to this ſemidiameter find *A C* a chord of 36 *gr.* this *A C* ſhall be the greater ſegment, diuiding the whole line in *C*, by extreme and meane proportion. So that,

As *A B* the whole line is vnto *A C* the greater ſegment:
ſo *A C* the greater ſegment vnto *C B* the leſſer ſegment.

Or let *A C* be the greater ſegment giuen: if I make this a parallell chord of 36 *gr.* the correſpondent ſemidiameter ſhall be the whole line *A C*, and the difference *C B* the leſſer ſegment.

Or let *C B* be the leſſer ſegment giuen: if I make this a parallell chord of 36 *gr.* the correſpondent ſemidiameter

ſhall be greater ſegment *A C*, which added to C B, giueth the whole line A B.

To auoid doubling of lines or numbers, you may put ouer the whole line in the *Sines* of 72 *gr.* and the parallell ſine of 36 *gr.* ſhall be the greater ſegment.

Or if you put ouer the whole line in the ſines of 54 *gr.* the parallell ſine of 30 *gr.* ſhall be the greater ſegment, and the parallell ſine of 18 *gr.* ſhall be the leſſer ſegment.

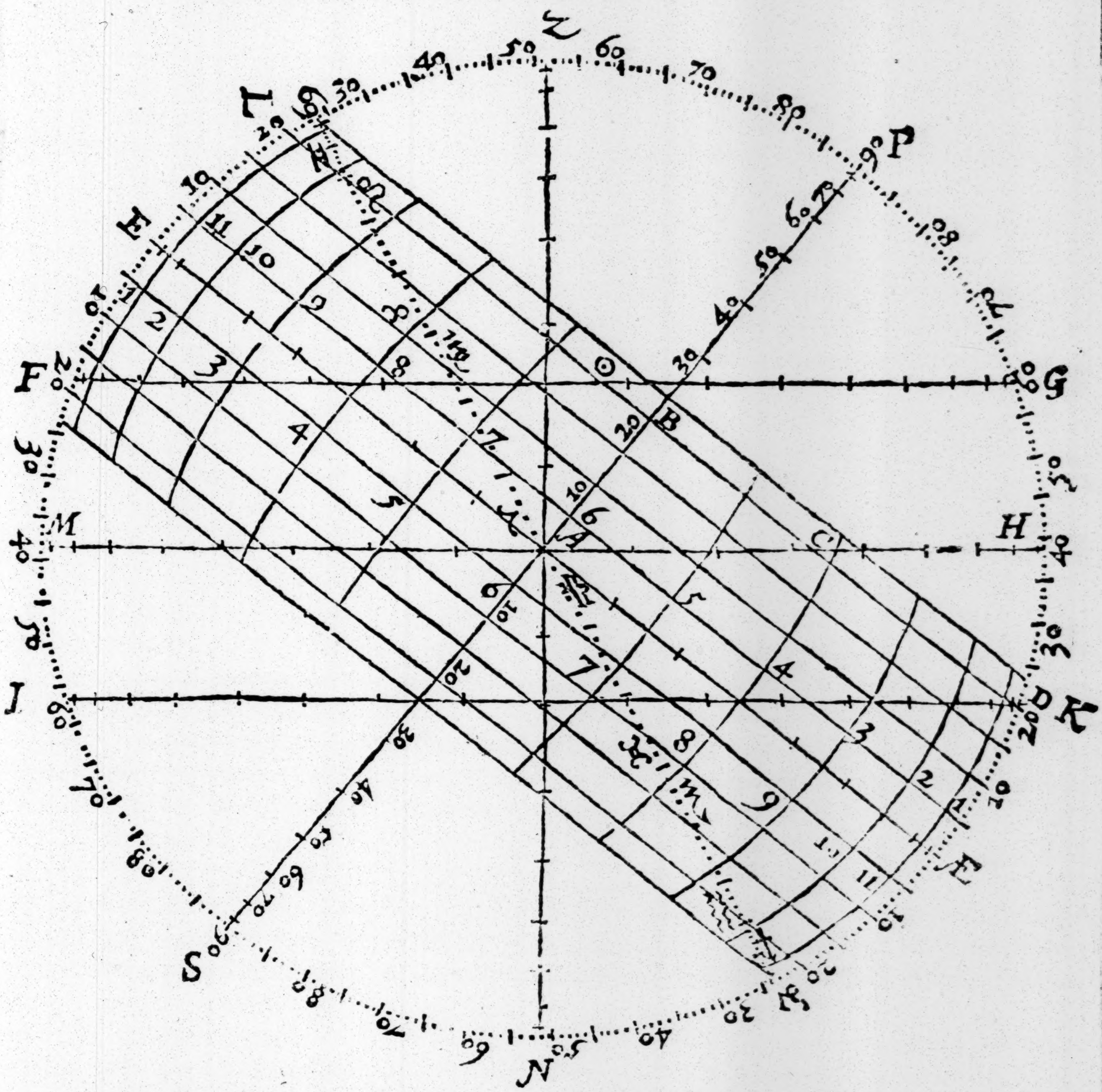
CHAP. III.

Of the proiection of the Sphere in Plano.

1 THe Sphere may be proiected in *Plano* in ſtreight lines, as in the *Analemma*, if the ſemidiameter of the circle giuen be diuided in ſuch ſort as the line of *Sines* on the Sector.

As if the Radius of the circle giuen were *A E*, the circle thereon deſcribed may repreſent the plane of the generall meridian, which diuided into foure equal parts in *E*, *P*, *Æ*, *S*, and croſſed at right angles with *E Æ* and *P S*, the diameter *E Æ* ſhall repreſent the equator, and *P S* the circle of the houre of *6*. And it is alſo the axis of the world, wherein *P* ſtands for the North pole, and *S* for the South pole. Then may each quarter of the meridian be diuided into 90 *gr.* from the equator towards the poles. In which if we number 23 *gr.* 30 *m.* the greateſt declination of the Sun from *E* to *69* Northwards, from *Æ* to ♑ Southward, the line drawne from *69* to ♑ ſhal be the ecliptique, and the lines drawne parallell to the equator through ♋ and ♑ ſhall be the tropiques.

Hauing theſe common ſections with the plane of the meridian, if we ſhall diuide each diameter of the Ecliptique into 90 *gr.* in ſuch ſort as the *Sines* are diuided on the Sector. The firſt 30 *gr.* from *A* toward *69*, ſhall ſtand for the ſine of ♈. The 30 *gr.* next following for ♉. The reſt for ♊. ♋. ♌. &c. in their order. So that by theſe meanes we haue the place of the Sun for all times of the yeare.



If againe we diuide *A P*, *A S*, in the like sort, and set to the numbers 10. 20. 30. &c. vnto 90 *gr.* the lines drawne through each of these degrees parallell to the equator, shall shew the declination of the Sunne, and represent the parallels of latitude.

If farther we diuide *A E*, *A Æ*, and his parallels in the like sort, and then carefully draw a line through each 15 *gr.* so as it makes no angles; the lines so drawne shall be *ellipticall* and represent the houre-circles. The meridian *P E S* the houre

houre of 12 at noone; that next vnto it drawne through 75 *gr.* from the center the houres of 11 and 1, that which is drawne through 60 *gr.* from the center the houres of 10 and 2, &c.

Then hauing respect vnto the latitude, we may number it from *E* Northward vnto *Z*, and there place the zenith: by which and the center the line drawne *Z A N* shall represent the verticall circle, passing through the zenith and nadir East and West, and the line *M A H* crossing it at right angles shall represent the horizon.

These two being diuided in the same sort as the ecliptique and the equator, the line drawne through each degree of the semidiameter *A Z*, parallell to the horizon, shall be the circles of altitude, and the diuisions in the horizon and his parallels shall giue the azimuth.

Lastly, if through 18 *gr.* in *A N*, be drawne a right line *I K* parallell to the horizon, it shall shew the time when the day breaketh, and the end of the twilight.

For example of this proiection, let the place of the Sunne be the last degree of ♉, the parallell passing through this place is *L D*, and therefore the meridian altitude *M L*, and the depression below the horizon at midnight *H D*: the semidiurnall arke *L C*, the seminocturnall arke *C D*, the declination *A B*, the ascentionall difference *B C*, the amplitude of ascension *A C*. The difference betweene the end of twilight and the day breake is very small; for it seemes the parallell of the Sunne doth hardly crosse the line of twilight.

If the altitude of the Sunne be giuen, let a line be drawne for it parallell to the horizon; so it shall crosse the parallell of the Sunne, and there shew both the azimuth and the houre of the day. As if the place of the Sunne being giuen as before, the altitude in the morning were found to be 20 *gr.* the line *F G* drawne parallell to the horizon through 20 *gr.* in *A Z*, would crosse the parallell of the Sunne in ☉. Wherefore *F* ☉ sheweth the azimuth, & *L* ☉ the quantitie of houres from the meridian. It seemes to be about halfe an houre past 6 in the morning, and yet more then halfe a point

ſhort of the Eaſt.

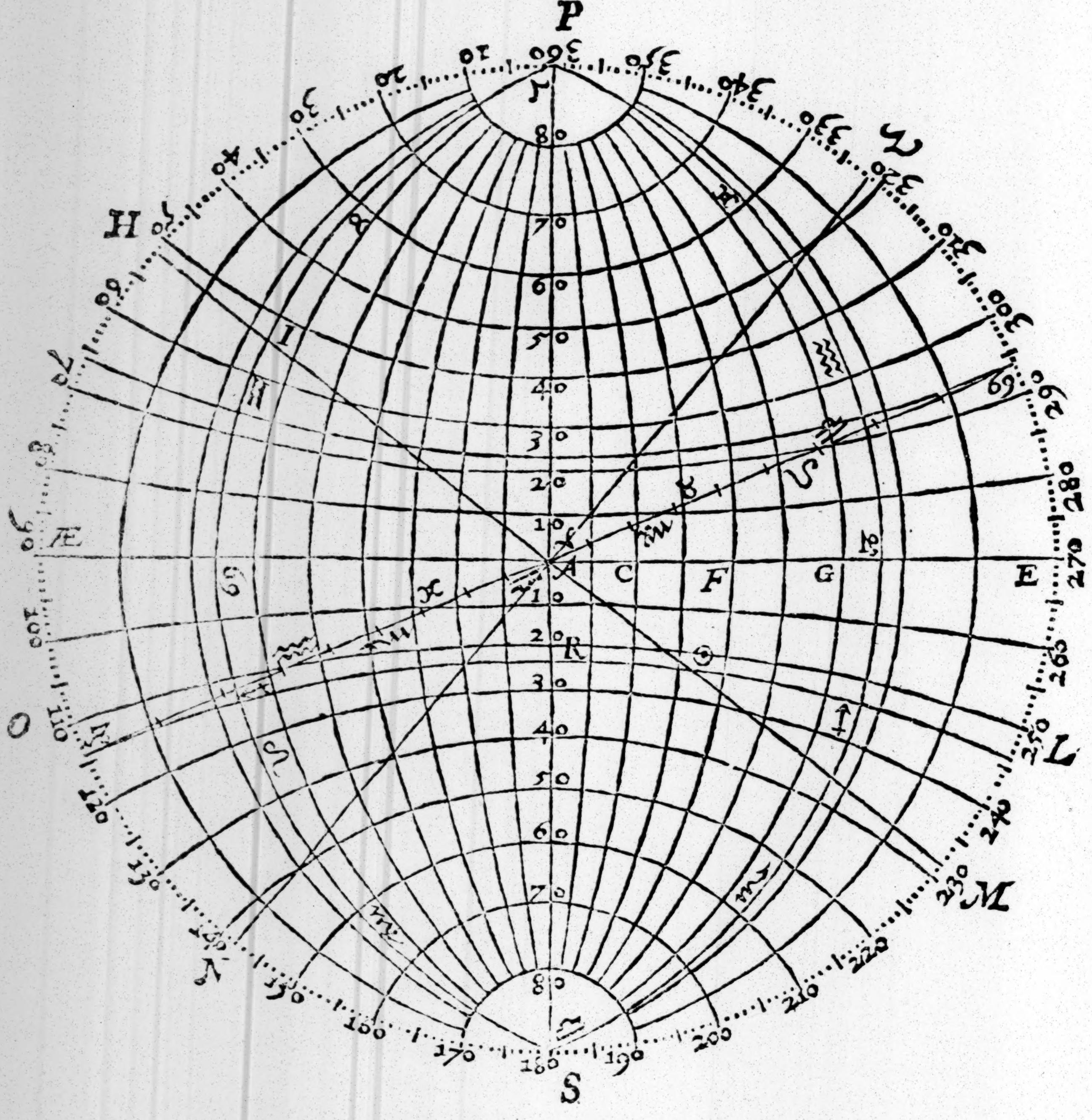
The diſtance of two places may be alſo ſhewed by this proiection, their latitudes being knowne, and their difference of longitude.

For ſuppoſe a place in the Eaſt of Arabia, hauing 20 *gr.* of North latitude, whoſe difference of longitude from London is found by an eclipſe to be 5 *ho.* $\frac{1}{2}$. Let Z be the zenith of London, the parallell of latitude for that other place muſt be *L D*, in which the difference of longitude is *L* ☉. Wherefore ☉ repreſenting the ſite of that place, I draw through ☉ a parallell to the horizon *M H*, croſſing the verticall *A Z* neare about 70 *gr.* from the zenith, which multiplied by 20, ſheweth the diſtance of London, and that place to be 1400 leagues. Or multiplied by 60, to be 4200 miles.

2 The Sphere may be proiected in *plano* by circular lines, as in the generall aſtrolabe of *Gemma Friſius*, by the help of the tangent on the ſide of the Sector.

For let the circle giuen repreſent the plane of the generall meridian as before; let it be diuided into foure parts, and croſſed at right angles with *E Æ* the equator, and *P S* the circle of the houre of 6, wherein *P* ſtands for the North pole, and *S* for the South pole. Let each quarter of the meridian be diuided into 90 *gr.* and ſo the whole into 360, beginning from *P*, and ſetting to the numbers of 10, 20, 30. &c. 90 at *Æ*, 180 at *S*, 270 at *E*, 360 at *P*. The ſemidiameters *A P*, *A Æ*, *A S*, *A E*, may be diuided according to the tangents of halfe their arkes, that is a tangent of 45 *gr.* which is alwayes equall to the Radius, ſhall giue the ſemidiameter of 90 *gr*; a tangent of 40 *gr.* ſhall giue 80 *gr.* in the ſemidiameter: a tangent of 35 *gr.* ſhall giue 70. &c. So that the ſemidiameters may be diuided in ſuch ſort as the tangent on the ſide of the Sector, the difference being onely in their numbers.

Hauing diuided the circumference and the ſemidiameters, we may eaſily draw the meridians and the parallels by the helpe of the Sector.



The meridians are to be drawne through both the pole
P and *S*, and the degrees before graduated in the equator
The diſtance of the center of each meridian from *A* the cen
ter of the plane, is equall to the tangent of the ſame meri
dian, reckoned from the generall meridian *P Æ S E*, an
the ſemidiameter equall to the ſecant of the ſame degree.
As for example, if I ſhould draw the meridian *P B S*, whic
is the tenth from *P Æ S*, the tangent of 10 *gr.* giueth m
Æ C, and the ſecant of 10 *gr.* giueth me *S C*, whereof *C* is th
cent

center of the meridian *P B S*, and *C S* his ſemidiameter : ſo *A F* a tangent of 20 *gr.* ſheweth *F* to be the center of *P D S*, the twentith meridian from *P Æ S*, and *A G* a tangent of 23 *gr.* 30 *M.* ſheweth *G* to be the center of *P* 69 *S.* &c.

The parallels are to be drawne through the degrees, in *A P*, *A S*, and their correſpondent degrees in the generall meridian. The diſtance of the center of each parallell from *A* the center of the plane, is equall to the ſecant of the ſame parallell from the pole, and the ſemidiameter equall to the tangent of the ſame degree. As if I ſhould draw the parallell of 80 *gr.* which is the tenth from the pole *S*, firſt I open the compaſſes vnto *A C* the tangent of 10 *gr.* and this giueth me the ſemidiameter of this parallel, whoſe center is a little from *S*, in ſuch diſtance as the ſecant *S C* is longer then the radius *S A*.

The meridians and parallels being drawne, if we number 23 *gr.* 30 *m.* from *E* to ♋ Northward, from *Æ* to ♑ Southward, the line drawne from ♋ to ♑ ſhall be the ecliptique : which being diuided in ſuch ſort as the ſemidiameter *A P*, the firſt 30 *gr.* from *A* to ♋ ſhall ſtand for the ſine of ♈; the 30 *gr.* next following for ♉; the reſt for ♊. ♋. ♌. &c. in their order.

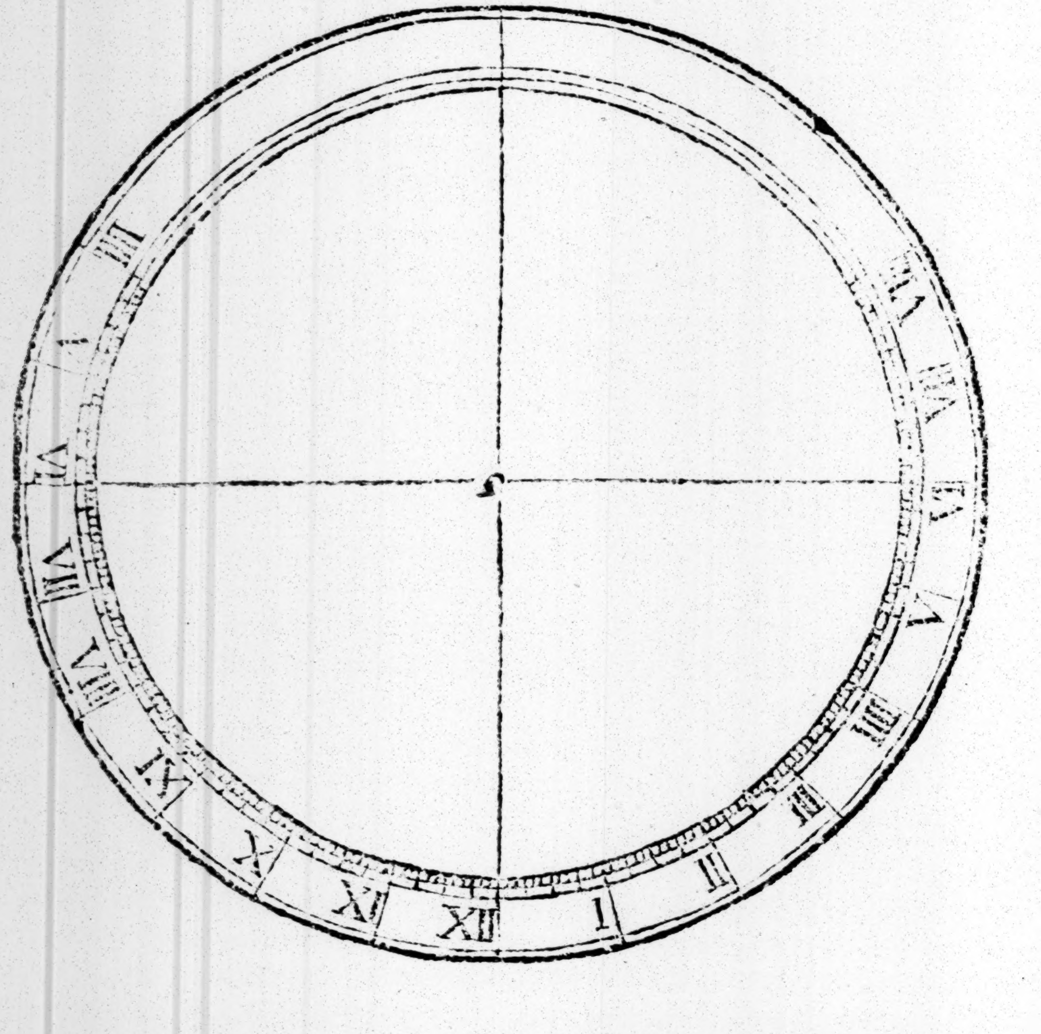
If farther we haue reſpect vnto the latitude, we may number it from *E* Northward vnto *Z*, and there place the zenith, by which and the center, the line drawne *Z A N* ſhall repreſent the verticall circle, and the line *M A H* croſſing it at right angles, ſhall repreſent the horizon ; and theſe diuided in the ſame ſort as *A P*, the circles drawne through each degree of the ſemidiameter *A Z*, parallell to the horizon, ſhall be the circles of altitude: and the circles drawne through the horizon and his poles, ſhall giue the azimuths.

For example of this proiection, let the place of the Sunne be in the beginning of ♒, the parallell paſſing through this place is ♒ ☉ *L*; and therefore the meridian altitude *M L*, and the depreſſion below the horizon at midnight *H* ♒, the ſemidiurnall arke *L* ☉, the ſeminocturnall arke *O* ♒, the declination *A R*, the aſcenſionall difference *R* ☉, the ampli-

tude of aſcenſion *A*☉.

Or if *A* be put to repreſent the pole of the world , t
ſhall *P ÆSE* ſtand for the equator , and *P* ♋ *S* ♑ for
ecliptique, and the reſt which before ſtood for meridi
may now ſerue for particular horizons, according to t
ſeuerall eleuations. Then ſuppoſe the place of the Sunne
giuen to be 24 *gr.* of ♉, his longitude ſhall be *PI*, his righ
cenſion *PH*, his declination *HI*. And if the place giue
19 *gr.* of ♌, his longitude ſhal be *PK*, his right aſcenſion
his declination NK. Againe, the declination brought to
horizon of the place, ſhall there ſhew the aſcentionall d
rence, amplitude of aſcenſion , and the like concluſion
the globe. But I intend not here to ſhew the vſe of th
ſtrolabe, but the vſe of the Sector in proiection.

And after this maner may a nocturnall be proiecte
ſhew the houre of the night , whereof I will ſet dow
type for the vſe of Sea-men.



It consists as you see of two parts, the one is a plane, diuided equally according to the 24 houres of the day, and each houre into quarters or minutes, as the plane will beare: the line from the center to XII, stands for the meridian, and XII stands for the houre of 12 at midnight. The other part is a rundle for such starres as are neare the North pole, together with the twelue moneths, and the dayes of each moneth fitted to the right ascension of the starres. Those that haue occasion to see the South pole, may do the like for the Southerne constellations, and put them in a rundle on the back of this plane, and so it may serue for all the world.

The vse of this nocturnall is easie and ready. For looke vp to the pole, and see what starres are neare the meridian, then place the rundle to the like situation, so the day of the moneth will shew the houre of the night.

3 The Sphere may be proiected in *plano* by circular lines, as in the particular Astrolabe of *Ioh. Stophlerin*, by help of the tangent, as before.

For let the circle giuen represent the tropique of ♑, let it be diuided into foure parts, and crossed at right angles with AC the equinoctiall colure, and MB the solstitiall colure, and generall meridian, the center *P* representing the pole of the world. Let each quarter be diuided into 90 *gr.* and so the whole into 360, beginning from *A* towards *B*. The meridian *PM*, or *PB*, may be diuided according to the tangent of halfe his arke. So as the arke from the North pole to the tropique of ♑, being 90 *gr.* and 23 *gr.* 30 *m.* that is 113 *gr* 30 *m.* and the halfe arke 56 *gr.* 45 *m.* the meridian shall be diuided into 90 *gr.* and 23 *gr.* 30 *m.* in such sort as the tangent of 56 *gr.* 45 *m.* on the side of the Sector is diuided into degrees and halfe degrees; of which *PÆ* the arke of the equator 90 *gr.* from the pole, shall be giuē by the tangent of 45 *gr.* And *P* 69 the arke of the Summer tropique 66 *gr.* 30 *m.* from the pole, shall be giuen by the tangent of 33 *gr.* 15 *m.* And the circles drawne vpon the center *P* through Æ and ♋, shall be the equator, and the Summer tropique.

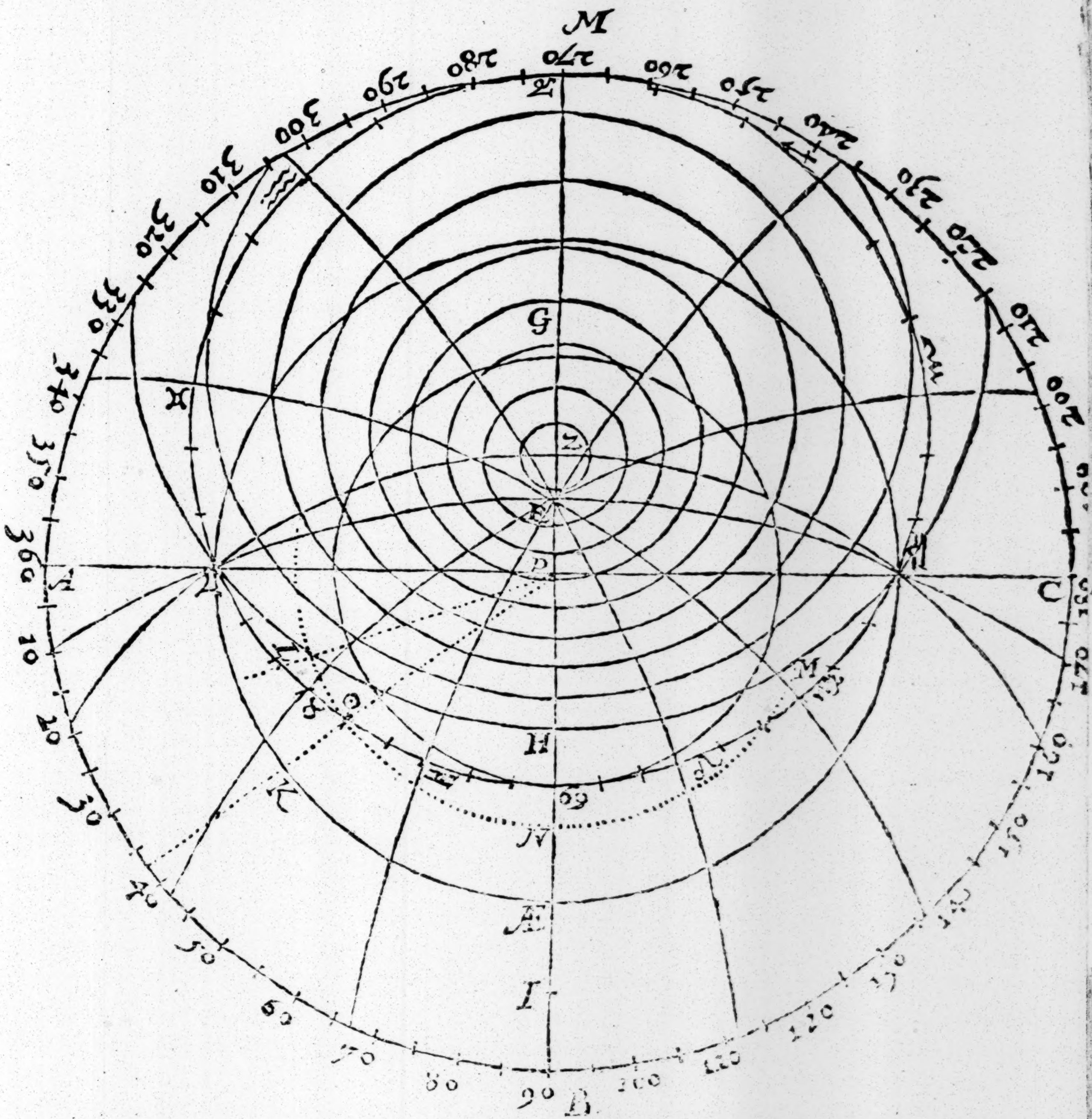
Hauing the equator and both the tropiques, the eclip-

tique ♈ ♋ ♎ ♑ shall be drawne from the one tropique to the other, through the intersection of the equator and the equinoctiall colure. And it may be diuided first into the twelue Signes after this maner: *P E* the arke of the pole of the ecliptique 23 *gr.* 30 *m.* from the pole of the world, shall be giuen by the tangent of 11 *gr.* 45 *m.* The center of the circle of longitude passing through this pole *E* ♈ and ♎, shal be found at *D* (somewhat below *B*) by the tangent of 66 *gr.* 30 *m.* Then through *D* draw an occult line parallell to *A C*, and diuide it on each side from *D*, in such sort as the tangent is diuided on the side of the *Sector*, allowing 45 *gr.* to be equall to *D E*. So the thirtith degree from D toward the right hand, shall be the center of the circle of longitude passing through *E* ♉ and ♏. The sixtith degree, the center of ♊ *E* ♐. The thirtith degree from D toward the left hand, the center of ♓ *E* ♍. The sixtith, the center of ♒ *E* ♌. And the other intermediate degrees shal be the centers to diuide each Signe into 30 *gr.*

If farther we haue respect vnto the latitude, we may (the meridian being before diuided) number it from *P* Northward vnto *H*, and there place the North intersection of the meridian and horizon: then the complement of the latitude being numbred from *P* Southward vnto *Z*, shall there giue the zenith; and 90 *gr.* from *Z* Southward vnto *F*, shall there giue the South intersection of the meridian and horizon. The middle betweene *F* and *H* shall be *G* the center of the horizon ♈ *H* ♎ *F*, passing through the beginning of ♈ and ♎, vnlesse there be some former error.

All parallels to the horizon may be found in like sort by their intersections with the meridian, and the middle betweene those intersections is alwayes the center.

The azimuths may be drawne as the circles of longitude were before. For the center of the first verticall ♈ *Z* ♎ will be found at *I* (somewhat neare vnto *B*) by the tangent of the latitude. And if through *I* we draw an occult line parallell to *A C*, and diuide it on each side from *I*, in such sort as the tangent is diuided on the side of the *Sector*, allowing 45 *gr.* to be equall



equall to 1*Z*; theſe diuiſions ſhall be the centers, and the diſtance from theſe diuiſions vnto *Z*, ſhall be the ſemidiameters whereon to deſcribe the reſt of the azimuths.

For example of this proiection, let ⊙ the place of the Sun giuen be 10 *gr.* of ♉: a right line drawne from *P* through this place vnto the equator, ſhall there ſhew his right aſcenſion ♈*K*, and his declination *K* ⊙. Then may we on the center *P* and ſemidiameter ⊙ *P*, draw an occult parallell of declinatiõ, croſſing the horizon in *L* and *M*, the meridian in *G* and N.

So the right lines *P L* and *P M* produced, shall shew the time of the Sunnes rising and setting, ♈ *Q* the difference of ascension, ♎ *R* the difference of descension, ♈ *L* the amplitude of his rising, and ♎ *M* the amplitude of his setting. *L G M* sheweth the length of the day, *L N M* the length of the night. *Z G* sheweth his distance from the zenith at noone, H N his depression below the horizon at midnight. And then hauing the altitude of the Sunne at any time of the day, the intersection of the parallell of altitude with the parallell of declination, sheweth the azimuth, and a right line drawne from *P* through this intersectiõ, giueth the houre of the day.

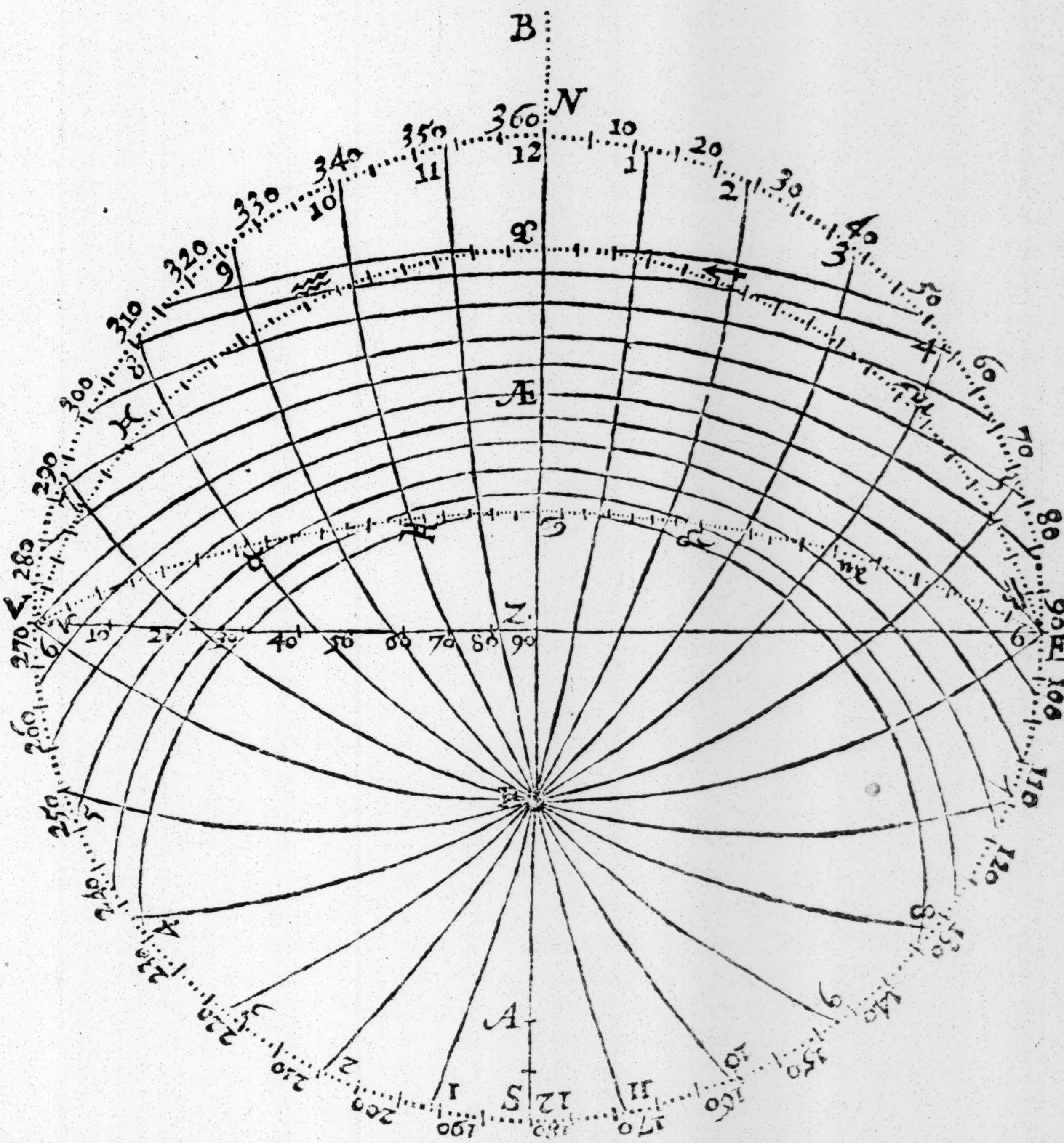
4 The Sphere may be proiected in *plano* by circular lines, after the maner of the old concaue hemisphere, by the help of the tangent on the side of the Sector.

For let the circle giuen represent the plane of the horizon, let it be diuided into foure parts, and crossed at right angles with *S* N the meridian, and *E V* the verticall; so as *S* may stand for the South, N for the North, *E* the East, *V* the West part of the horizon, and the center *Z* representeth the zenith. Let each quarter of the horizon be diuided into 90 *gr.* and so the whole into 360 *gr.* beginning from N, and setting to the numbers of 10. 20. 30. &c. 90 at *E*, 180 at *S*, 270 at *V*, 360 at N.

The semidiameters *Z* N, *Z S*, may be diuided according to the tangent of halfe their arkes: So as the arke from the zenith to the horizon being 90 *gr.* and the halfe arke 45 *gr.* the semidiameters are to be diuided in such sort as the tangent of 45 *gr.* as was shewed before in the second proiection. And if from *Z* we draw circles through each of these diuisions, they shall be parallels of altitude.

Then hauing respect vnto the latitude, we may (the meridian being before diuided) number it from *Z* to *Æ*, and there place the intersection of the meridian and equator. The complement of the latitude from *Z* vnto *P*, shall there giue the pole of the world, and 90 further from *P* shall there giue the other intersection of the meridian and equator.

The



The middle betweene these intersections shall be *A*, the center of the equator, passing through *E* and *V*, vnlesse there be some former error. The intersections of the tropiques depend on the equator. From *Æ* 23 *gr.* 30 *m.* farther shal be ♑, the intersection of the meridian & the Southerne tropique. From *Æ* 23 *gr.* 30 *m.* nearer shall be ♋, the intersection of the meridian and the Northerne tropique. The intersections of the other intermediat parallels, shall be giuen in like sort, by their degrees of distance from the equator, and the middle

betweene those interſections is alwayes the center.

The houre circles may be here drawne as the azimuths in the third proiection. For the center of *E P V*, the houre of 6 will be found at *B* (ſomewhat neare vnto N) by the tangent of the latitude. And if through *B* we draw an occult line parallell vnto *E V*, and diuide it on each ſide from *B*, in ſuch ſort as the tangent is diuided on the ſide of the Sector, allowing 45 *gr.* to be equall to *B P*, and 15 *gr.* for euery houre: thoſe diuiſions ſhall be the centers, and the diſtance from theſe diuiſions vnto *P*, ſhall be the ſemidiameters, whereon to deſcribe the reſt of the houre circles.

The ecliptique may be drawne as the equator. For the center of that halfe which hath Southerne declination, ſhall be giuen by the tangent of the altitude, which the Sun hath at his entrance into ♑. And the center of the other halfe, by the tangent of his altitude, at his entrance into ♋. And it may be diuided, as in the former proiection, or elſe by tables calculated to that purpoſe.

To theſe circles thus drawne, if we ſhall adde the moneths of the yeare, and the dayes of each moneth, as we may well doe, at the horizon, on either ſide betweene the tropiques; this proiection ſhall be fitted for the moſt vſefull concluſions of the globe.

For the day of the moneth being giuen, the parallell that goeth on it, doth ſhew what declination the Sunne hath at that time of the yeare. And where this parallell croſſeth the ecliptique, there is the place of the Sunne. Or the place of the Sunne being firſt giuen, the parallell which croſſeth it ſhall at the horizon ſhew the day of the moneth. Either of theſe then being giuen, or onely the parallell of declination, we may follow it firſt vnto the horizon, there the diſtance of [illegible] of the parallell from *E* or *V*, ſheweth the ampli[illegible] ſame among the houre circles ſheweth the time [illegible] he riſeth or ſetteth. Then hauing the altitude [illegible] any time of the day, the interſection of the [illegible] on, with the parallell of altitude, ſheweth [illegible] ay; and a right line drawne from Z

through

through this interſection to the horizon, giueth the azimuth.

Thus in either of theſe proiections, that which is otherwiſe moſt troubleſome, is eaſily done by the help of the *tangent* line: and what I haue ſaid of this line, the ſame may be wrought by ſcale and numbers out of the table of Tangents.

CHAP. IV.

Of the reſolution of right-line Triangles.

IN all Triangles there being ſix parts, viz. three angles and three ſides, any three of them being giuen, the reſt may be found by the Sector.

As in a Rectangle triangle,
1 *To finde the baſe, both ſides being giuen.*

Let the *Sector* be opened in the lines of *Lines* to a right angle, (as before was ſhewed *Cap.2. Prop.7.*) then take out the ſides of the triangle, and lay them, one on one line, the other on the other line, ſo as they meete in the center, and marke how farre they extend. For the line taken from the termes of their extenſion, ſhall be the baſe required, viz. the ſide oppoſite to the right angle.

Or adde the ſquares of the two ſides (as in *Prop.4. Superf.*) and the ſide of the compound ſquare ſhall be the baſe.

2 *To find the baſe by hauing the angles, and one of the ſides giuen.*

Take the ſide giuen, and turne it into the parallell ſine of his oppoſite angle; ſo the parallell Radius ſhall be the baſe.

3 *To find a ſide by hauing the baſe, and the other ſide giuen.*

Let the Sector be opened in the lines of *lines* to a right

 angle,

angle, and the side ginen laid on one of those lines from the center; then take the base with a paire of compasses, and setting one foote in the terme of the giuen side, turne the other to the other line of the Sector, and it shall there shew the side required.

Or take the square of the side out of the square of the base (as in *Prop.4. Superf.*) and the side of the remaining square shall be the side required.

4 *To find a side hauing the base and the angles giuen.*

Take the base giuen, and make it a parallell Radius, so the parallell *sines* of the angles, shall be the opposite sides required.

5 *To find a side by hauing the other side and the angles giuen.*

Take the side giuen, and turne it into his parallell *sine* of his opposite angle; so the parallell *sine* of the complement shall be the side required.

6 *To find the angles by hauing the base and one of the sides giuen.*

First take out the base giuen, and laying it on both sides of the Sector, so as they may meete in the center, and marke how farre it extendeth. Then take out the laterall Radius, and to it open the Sector in the termes of the base. This done, take out the side giuen, and place it also on the same lines of the Sector from the center. For the parallell taken in the termes of this side, shall be the sine of his opposite angle.

Or take the base giuen, and make it a parallell Radius, then take the side giuen, and carrie it parallell to the base, till it stay in like *sines*: so they shall giue the quantitie of the

the opposite angle.

7 *To finde the angles by hauing both the sides giuen.*

Take out the greater side, and lay it on both sides of the Sector, so as they meete in the center, and marke how farre it extendeth. Then take the other side, and to it open the Sector in the termes of the greater side; so the parallell Radius shall be the tangent of the lesser angle. The third angle is alwayes knowne by the complement.

8 *The Radius being giuen, to find the tangent, and secant of any arke.*

9 *The tangent of any arke being giuen, to find the tangent thereof, and the Radius.*

10 *The secant of any arke being giuen, to find the tangent thereof, and the Radius.*

The tangent, and the secant, together with the Radius of euery arke, do make a right angle triangle; whose sides are the *Radius* and *tangent*, and the base alwayes the *secant*; and the angles alwayes knowne by reason of the giuen arke. Wherefore the solution is the same with those before.

In any right-lined triangle whatsoeuer,

11 *To find a side by knowing the other two sides, and the angle contained by them.*

Let the *Sector* be opened in the lines of *lines* to the angle giuen, then take out the sides of the triangle, & laying them the one on the one line, the other on the other, so as they meete in the center, marke how far they extend. For the line taken betweene the termes of their extension, shall be the third side required.

12 *To find a side by hauing the other two sides, and one of the adiacent angles, so it be knowne which of the other angles is acute or oblique.*

Let the *Sector* be opened in the lines of *lines* to the angle giuen, and the adiacent side layd on one of those lines from the center; then take the other side with a paire of compasses, and setting one foote in the terme of the former giuen side, turne the other to the other line of the *Sector* which here representeth the side required, and it shall crosse it in two places; but with which of them is the terme of the side required, must be iudged by the angle.

As if in the triangle following, the side *A C* being giuen, and the side *C D* and the angle *C A D* 18 *gr.* 40 *m.* it were required to find the side *A D.*

First I open the Sector in the lines of *lines* to an angle of 18 *gr.* 40 *m.* and laying the adiacent side from the center *A*, it extendeth to 800 in *C*. Then I take the other side *CD* with the compasses, and setting one foote in *C*, and turning the other to the other line of the *Sector*, I find that it doth crosse it both in *B* and D; so that it is vncertaine whither the side required be *A B* or *A D*, onely it may be iudged by the angle. For if the inward angle where they crosse be obtuse, the side required is the lesser; if it be acute, it is the greater.

13 *To find a side by hauing the angles and one of the other sides giuen.*

Take the side giuen, and turne it into the parallell sine of his opposite angle; so the parallell sines of the other angle shall be the opposite sides required.

14 To find the proportion of the sides by hauing the three angles.

Take the laterall sines of the angles, and measure them in the line of *lines*. For the numbers belonging to those lines do giue the proportion of the sides.

15 To finde an angle by knowing the three sides.

Let the two containing sides be layd on the lines of the *Sector* from the center, one on one line, and the other on the other; and let the third side, which is opposite to the angle required, be fitted ouer in their termes: so shall the *Sector* be opened in those lines to the quantitie of the angle required. The quantitie of this angle is found as in *Cap.2. Prop*.8.

16 To finde an angle by hauing two sides and one adiacent angle.

First take out the side opposite to the angle giuen, and laying it on both sides of the Sector, so as they meete in the center, marke how farre it extendeth; then take out the laterall sine of the angle, and to it open the Sector in the termes of the first side: this done, take out the other side giuen, and place it also on the same lines of the Sector from the center, for the parallels taken in the termes of this side, shall be the sine of the angle opposite to the second side.

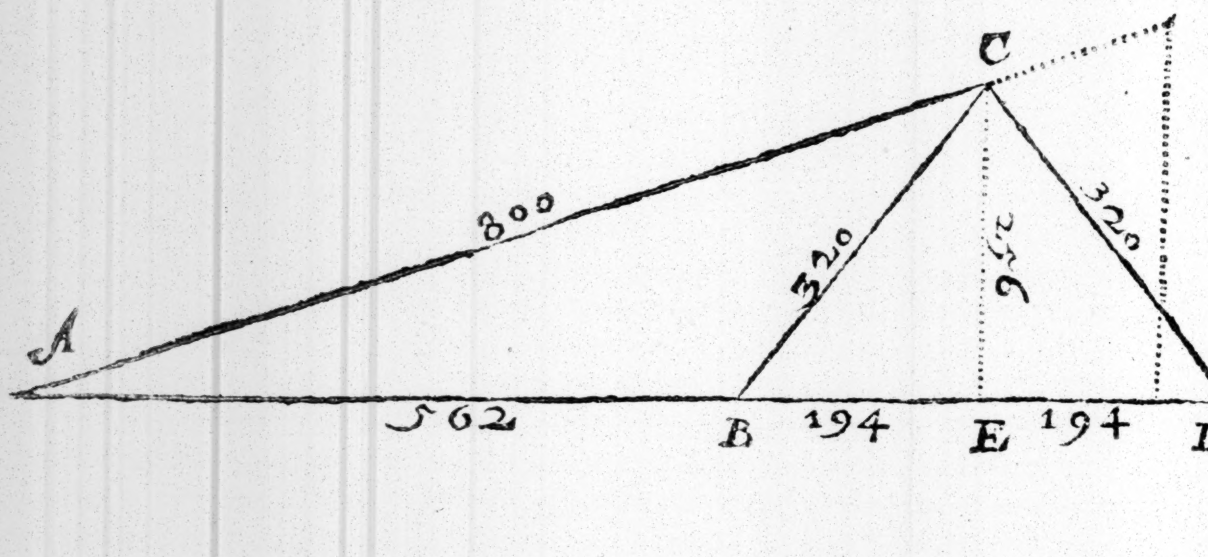
Or take out the side opposite to the angle giuen, and make it a parallell sine of that angle; then take the other side giuen and carrie it parallell to the former, till it stay in like sines: so they shall giue the quantitie of the angle opposite to the second side.

17 *To finde an angle by hauing two sides, and the angle contained by them.*

First find the third side by the 11.*Prop.* and then the a-
gles may be found by the 15.or 16.*Prop.*

For practise in each of these cases, we may vse the exam-
ples following, wherein *C E A, C E B, C E D* are rectang-
in *E*; the rest consist of oblique angles.

C A B	18 *gr.*	40 *m.*
A B C	126	52
A C B	34	28
A C D	108	12
A D C	53	8
B C D	73	44



For obseruation of angles, the *Sector* may haue sights
on the moueable foote; so that by looking through them
the edges of the Sector may be applied to the sides of t-
angle.

F

For measuring of the sides of lesser triangles, any scale may suffice, either of feete, or inches, or lesser parts. But for greater triangles, especially for plotting of grounds, I hold it fit to vse a chaine of foure perches in length, diuided into an hundred links. For so the length being multiplied into the bredth, the fiue last figures giue the content in roods and perches by this Table; the other figures toward the left hand, doe shew the number of acres directly.

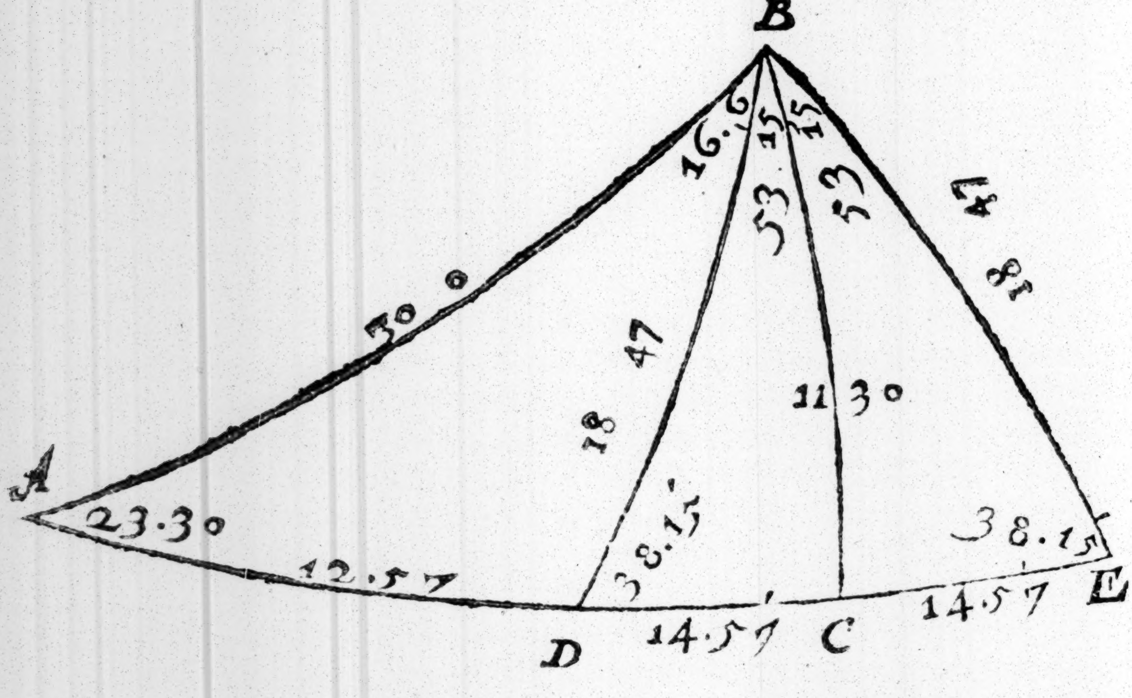
As if in the former triãgle *ACD*, the length *AD* be 9 chaines and 50 links, the bredth *CE* be 2 chaines and 56 links; these multiplied giue the content for the long square 2.43200, the halfe whereof for the triangle is 1.21600, that is 1 acre, 21600 parts of 100000, of which last fiue figures, 20000 giue 32 perches, and the remainder 1600 giue better then two perches more.

Links	*R*	*P*
100000	4	0
90000	3	24
80000	3	8
70000	2	32
60000	2	16
50000	2	0
40000	1	24
30000	1	8
20000		32
10000		16
9375		15
8750		14
8125		13
7500		12
6875		11
6250		10
5625		9
5000		8
4375		7
3750		6
3125		5
2500		4
1875		3
1250		2
625		1

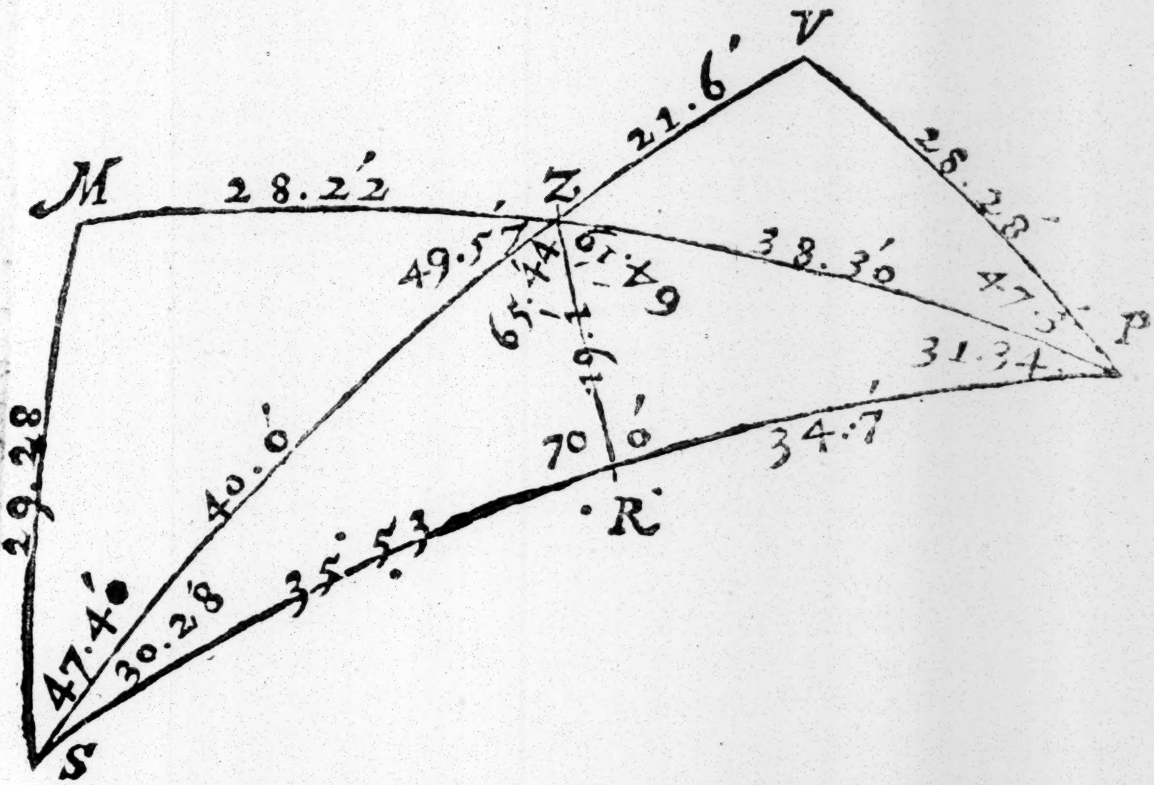
CHAP. V.

Of the resolution of sphericall triangles.

FOr our practise in sphericall triangles, let *A* be the equinoctiall point, *A* B an arke of the ecliptique representing the longitude of the Sunne in the beginning of ♉, *B C* an arke of the declination from the Sunne to the equator, and *A C* an arke of the equator representing the right ascension.



Let B D be an arke of the horizon representing the amplitude of the Sunnes rising from the East, and *B E* an arke of the horizon for his setting from the West: so D C shall be the difference of ascension, and *C E* the difference of descension; A D the oblique ascension, and *A E* the oblique descension of the same place of the Sunne in our latitude at *Oxford* of 51 *gr.* 45 *m.* whose complement 38 *gr.* 15 *m.* is the angle at *E* and D. The triangles *A C B*, D *C B*, *E C B*, are rectangle in *C*: the other *A* D *B*, *A E B*, consist euery way of oblique angles.



Or to fit an example nearer to the latitude of *London.* Let *Z P S* represent the zenith pole and Sun, *Z P* being 38 *gr.* 30 *m.* the complement of the latitude, *P S* 70 *gr.* the complement of the declination, and *Z S* 40 *gr.* the complement of the Suns altitude. The angle at *Z* shall shew the azimuth, and the angle at *P*, the houre of the day from the meridian. Then if from *Z* to *P S* we let downe a perpendicular *Z R*, we shall reduce the oblique triangle into two rectangle triangles *Z R P*, *Z R S*. Or if from *S* to *Z P* we set downe a perpendicular *S M*, we shall reduce the same *Z P S* into two other triangles, *S M Z*, *S M P*, rectangle at *M*: whatsoeuer is said of any of these triangles, the same holdeth for all other triangles in the like cases.

For the resolution of each of these, there be seuerall wayes. I onely chuse those which are fittest for the *Sector*, wherein if that be remembred which before is shewed in the generall vse of the *Sector* concerning laterall and parallell entrance, it may suffice onely to set downe the proportion of the three parts giuen to the fourth required, and so I shew first by the *sines* alone

In a rectangle triangle

1 To finde a side by knowing the base, and the angle opposite to the required side.

As the Radius
is to the sine of the base:
So the sine of the opposite angle
to the sine of the side required.

As in the rectangle *A C B*, hauing the base *AB*, the place of the Sunne 30 *gr.* from the equinoctiall point, and the angle *B A C* of 23 *gr.* 30 *m.* the greatest declination, if it were required to find the side *B C* the declination of the Sunne.

Take either the laterall sine of 23 *gr.* 30 *m.* and make it a parallell Radius; so the parallell sine of 30 *gr.* taken and measured in the side of the Sector, shall giue the side required 11 *gr.* 30 *m.* Or take the sine of 30 *gr.* and make it a parallell Radius; so the parallell sine of 23 *gr.* 30 *m.* taken and measured in the laterall sines, shall be 11 *gr.* 30 *m.* as before.

So in the triangle Z *P S* hauing Z *P* 38 *gr.* 30 *m.* and the angle *P* 31 *gr.* 34 *m.* giuen, we shall find the perpendicular Z *R* to be 19 *gr.* 1 *m*; or hauing *P S* 70 *gr.* and the said angle *P* 31 *gr.* 34 *m.* giuen, we may finde the perpendicular *S M* to be 29 *gr.* 28 *m.*

2 To finde a side by knowing the base and the other side.

As the sine of the complement of the side giuen
is to the Radius:
So the sine of the complement of the base
to the sine of the complement of the side required.

So in the rectangle *A C B*, hauing *A B* 30 *gr.* and *BC* 11 *gr.* 30 *m.* giuen, the side *A C* will be found 27 *gr.* 54 *m.*

Or in the rectangle *Z R P* hauing Z *P* 38 *gr.* 30 *m.* and Z *R* 19 *gr.* 1 *m.* giuen, the side *R P* will be found 34 *gr.* 7 *m.*

3 *To find a side by knowing the two oblique angles.*

As the sine of either angle
to the sine of the complement of the other angle:
So is the Radius
to the sine of the complement of the side opposite
to the second angle.

So in the rectangle *A C B*, hauing *C A B* for the first angle 23 *gr*. 30 *m*. and *A B C* for the second 69 *gr*. 21 *m*. the side *A C* will be found 27 *gr*. 54 *m*. Or making *A B C* the first angle, and *C A* B the second, the side BC will be found 11 *gr*. 30 *m*.

4 *To finde the base by knowing both the sides.*

As the Radius
to the sine of the complement of the one side:
So the sine of the complement of the other side,
to the sine of the complement of the base required.

So in the rectangle *A C*B hauing *A C* 27 *gr*. 54 *m*. and BC 11 *gr*. 30 *m*. the base *A* B will be found 30 *gr*.

5 *To finde the base by knowing the one side, and the angle opposite to that side.*

As the sine of the angle giuen,
to the sine of the side giuen:
So is the Radius
to the sine of the base required.

So in the rectangle B C D, knowing the latitude and the declination, we may find the amplitude; as hauing B C the side of the declination 11 *gr*. 30 *m*. and B DC the angle of the complement of the latitude 38 *gr*. 15 *m*. the base B D which is the amplitude, will be found to be 18 *gr*. 47 *m*.

6 *To find an angle by the other oblique angle, and the side opposite to the inquired angle.*

As the Radius
to the sine of the complement of the side:
So the sine of the angle giuen,
to the sine of the complement of the angle required.

So in the rectangle A C B, hauing the angle B A C 23 *gr.* 30 *m.* and the side A C 27 *gr.* 54 *m.* the angle A B C will be found 69 *gr.* 21 *m.*

7 *To finde an angle by the other oblique angle, and the side opposite to the angle giuen.*

As the sine of the complement of the side
to the side of the complement of the angle giuen:
So is the Radius
to the sine of the angle required.

So in the rectangle A C B, hauing B A C 23 *gr.* 30 *m.* and B C 11 *gr.* 30 *m.* the angle A B C will be found 69 *gr.* 21 *m.*

8 *To finde an angle by the base, and the side opposite to the inquired angle.*

As the sine of the base
is to the Radius:
So the sine of the side
to the sine of the angle required.

So in the rectangle B C D, hauing B D 18 *gr.* 47 *m.* and B C 11 *gr.* 30 *m.* the angle B D C will be found 38 *gr.* 15 *m.*

These eight Propositions haue been wrought by the *sines* alone; those which follow require ioynt help of the *tangent.*

And forasmuch as the *tangent* could not well be extended beyond 63 *gr.* 30 *m.* I shall set downe two wayes for the resolution of each Proposition; if the one will not hold, the other may.

9 *To finde a ſide by hauing the other ſide, and the angle oppoſite to the inquired ſine.*

1 As the Radius
to the ſine of the ſide giuen:
So the tangent of the angle,
to the tangent of the ſide required.

2 As the ſine of the ſide giuen,
is to the Radius:
So the tangent of the complement of the angle,
to the tangent of the complement of the ſide required.

So in the rectangle ACB, hauing the right ſide AC 27 *gr.* 54 *m,* and the angle B A C 23 *gr.* 30 *m.* the ſide B C will be found to be 11 *gr.* 30 *m.*

10 *To find a ſide, by hauing the other ſide, and the angle adiacent next to the inquired ſide.*

1 As the tangent of the angle,
to the tangent of the ſide giuen:
So is the Radius
to the ſine of the ſide required.

2 As the tangent of the complement of the ſide,
to the tangent of the complement of the angle.
So is the Radius
to the ſine of the ſide required.

This and the like, where the tangent ſtandeth in the firſt place, are beſt wrought by parallelſ entrance. And ſo in the rectangle BC D, hauing B C the ſide of declination 11 *gr.* 30 *m.* and B D C the angle of the complement of the latitude 38 *gr.* 15 *m.* the ſide D C, which is the aſcenſionall difference, will be found 14 *gr.* 57 *m.*

By the aſcenſionall difference is giuen the time of the Sunnes riſing and ſetting, and length of the day, allowing

an

an houre for each 15 *gr.* and 4 minutes of time for each seuerall degree. As in the example the difference betweene the Sunnes ascension in a right sphere, which is alwayes at 6 of the clocke, and his ascension in our latitude being 14 *gr.* 57 *m.* it sheweth that the Sunne riseth very neare an houre before 6, because of the Northerne declination; or after 6, if the Sunne be declining to the Southward.

11 *To finde a side by knowing the base, and the angle adiacent next to the inquired side.*

1 As the Radius
to the sine of the complement of the angle:
So is the tangent of the base,
to the tangent of the side required.

2 As the sine of the complement of the angle
is to the Radius:
So the tangent of the complement of the base,
to the tangent of the complement of the side required.

So in the rectangle A C B, knowing the place of the Sun from the next equinoctiall point, and the angle of his greatest declination, we may find his right ascension: viz. the base A B 30 *gr.* and the angle BAC 23 *gr.* 30 *m.* being giuen, the right ascension A C will be found 27 *gr.* 54 *m.*

12 *To finde the base by knowing the oblique angles.*

As the tangent of the one angle,
to the tangent of the complement of the other angle:
So is the Radius
to the sine of the complement of the base.

So in the rectangle A C B, hauing B A C 23 *gr.* 30 *m.* and A B C 69 *gr.* 21 *m.* the base A B will be found 30 *gr.*

13 To

13 *To finde the baſe, by one of the ſides, and the angle adiacent next that ſide.*

1 As the Radius
is to the ſine of the complement of the angle:
So the tangent of the complement of the ſide,
to the tangent of the complement of the baſe.

2 As the ſine of the complement of the angle
is to the Radius:
So the tangent of the ſide giuen,
to the tangent of the baſe required.

So in the rectangle *A C B*, hauing *A C* 27 *gr*. 54 *m*. and *B AC* 23 *gr*. 30 *m*. the baſe A B will be found 30 *gr*. 0 *m*.

14 *To find an angle, by knowing both the ſides.*

1 As the Radius
is to the ſine of the ſide next the inquired angle:
So the tangent of the complement of the oppoſite ſide,
to the tangent of the complement of the angle required.

2 As the ſine of the ſide next the inquired angle,
is to the Radius:
So the tangent of the oppoſite ſide,
to the tangent of the angle required.

So in the rectangle A C B, hauing A C 27 *gr*. 54 *m*. and B C 11 *gr*. 30 *m*. the angle at *A* will be found 23 *gr*. 30 *m*. and the angle at B 69 *gr*. 21 *m*.

15 *To finde an angle, by the baſe, and the ſide adiacent to the inquired angle.*

1 As the tangent of the complement of the ſide,
to the tangent of the complement of the baſe:

So is the Radius
to the sine of the complement of the angle required.

2 As the tangent of the base,
to the tangent of the side:
So is the Radius,
to the sine of the complement of the angle required.

So in the rectangle BCD, hauing the base BD 18 *gr*. 47 *m* and the side BC 11 *gr*. 30 *m*. the angle D B C between them will be found 53 *gr*. 15 *m*.

16 *To find an angle, by knowing the other oblique angle, and the base.*

1 As the Radius,
to the sine of the complement of the base:
So the tangent of the angle giuen,
to the tangent of the complement of the angle required.

2 As the sine of the complement of the base,
is to the Radius:
So the tangent of the complement of the angle giuen,
to the tangent of the angle required.

So in the rectangle A C B, hauing the angle at *A* 23 *gr*. 30 *m*. and the base A B 30 *gr*. the angle A B C will be found 69 *gr*. 21 *m*.

These sixteen cases are all that can fall out in a rectangle triangle: those which follow do hold

In any sphericall triangle whatsoeuer

17 *To find a side opposite to an angle giuen, by knowing one side, and two angles, whereof one is opposite to the giuen side, the other to the side required.*

As

As the sine of the angle opposite to the side giuen,
is to the sine of that side giuen:
So the sine of the angle opposite to the side required,
to the sine of the side required.

So in the triangle A B E, hauing the place of the *Sunne*, the latitude, and the greatest declination, we may finde the amplitude. As hauing A B 30 *gr*. BA E 23 *gr*. 30 *m*. and AEB 58 *gr*. 15 *m*. the side B E which is the amplitude, will be found 18 *gr*. 47 *m*.

18 *To finde an angle opposite to a side giuen, by hauing one angle and two sides, the one opposite to the giuen angle, the other to the angle required.*

As the sine of the side opposite to the angle giuen,
is to the sine of that angle giuen:
So the sine of the side opposite to the angle required,
to the sine of the angle required.

So in the triangle *Z P S*, hauing the azimuth, and latitude, and declination, we may find the houre of the day. As hauing *P Z S* 130 *gr*. 3 *m*. *PS* 70 *gr*. and *Z S* 40 *gr*. the angle *Z P S*, which sheweth the houre from the meridian shall be found 31 *gr*. 34 *m*.

19 *To find an angle by knowing the three sides.*

This proposition is most vsefull, but most difficult of all others: as in Arithmetique, so by the *Sector*, yet may it be performed seuerall wayes.

1 According to *Regiomontanus* and others.

As the sine of the lesser side next the angle required,
to the difference of the versed sines of the base and difference of the sides:
So is the Radius
to a fourth proportionall.

Then as the sine of the greater side next the angle required
is to that fourth proportionall :
So is the Radius
to the versed sine of the angle required.

So in the triangle *ZPS*, hauing the side *P S*, the cōplement of the declination 70 *gr.* 0 *m.* the side Z *P* the complement of the latitude 38 *gr.* 30 *m.* and the base Z *S* the complement of the altitude 40 *gr.* the angle of the houre of the day Z*PS* will be found 31 *gr.* 34 *m.* which is 2 *h.* 6 *m.* from the meridian.

For the base being 40 *gr.* 0 *m.* and the difference of the sides 38 *gr.* 30 *m.* and 70 *gr.* 0 *m.* being 31 *gr.* 30 *m.* the difference of their versed sines wil be the same with the distance betweene the right sine of 50 *gr.* and 58 *gr.* 30 *m.* This difference I take out, and make it a parallell sine of the lesser side 38 *gr.* 30 *m.* so the parallell Radius wil be the fourth proportionall. Then coming to the second operation, I make this fourth proportionall, a parallel sine of the greater side of 70 *gr.* 0 *m.* and take out his parallell Radius. For this measured from 90 *gr.* toward the center, will be the versed sine of 31 *gr.* 34 *m.*

In the like sort in the same triangle Z *P S*, hauing the same complements giuen, the angle *P* Z *S* which is the azimuth from the North part of the meridian, will be found 130 *gr.* 3 *m.* For here the base opposite to the angle required being 70 *gr.* and the difference of the sides 38 *gr.* 30 *m.* and 40 *gr.* being 1 *gr.* 30 *m.* the difference of their versed sines will be the same with the distance betweene the right sines of 20 *gr.* and 88 *gr.* 30 *m.* This difference I take, and make it a parallel sine of the lesser side 38 *gr.* 30 *m.* so the parallell Radius will be the fourth proportionall. Then coming to the second operation, I make this fourth proportionall a parallell sine of the greater side 40 *gr.* and take out his parallell Radius. For this measured from 90 *gr.* beyond the center in the lines of *sines* stretched forth at their full length, will be the versed sine of 130 *gr.* 3 *m.*

2 I may finde an angle by knowing three sides, by that which I haue elsewhere demonstrated vpon *Barth. Pitiscus*,

and

and that at one operation in this maner.

As the sine of the greater side
is to the secant of the complement of the other side:
So the difference of sines of the complement of the base, and the arke compounded of the lesser side with the complement of the greater,
to the versed sine of the angle required.

So in the same triangle Z *P S*, hauing the same complements giuen, the angle at *P*, which sheweth the houre from the meridian, will be found as before 31 *gr*. 34 *m*.

For the sides being 38 *gr*. 30 *m*. and 70 *gr*. 0 *m*. I take the secant of the complement of 38 *gr*. 30 *m*. and make it a parallell sine of 70 *gr*; then keeping the Sector at this angle, I consider that the complement of 70 *gr*. being 20 *gr*. added vnto 38 *gr*. 30 *m*. the compounded side (which is here the meridian altitude) will be 58 *gr*. 30 *m*; and that the base being 40 *gr*. the difference of sines of the compounded side and the complement of the base will be (as before) the distance betweene the sines of 50 *gr*. and 58 *gr*. 30 *m*. Wherefore I take out this difference, and lay it on both the lines of *sines* from the center: so the parallell taken in the termes of this difference, and measured from 90 *gr*. toward the center, doth giue the versed sine of 31 *gr*. 34 *m*.

The other angles *P* Z *S*, *P S* Z, may be found in the same sort; but hauing the sides and one angle, it will be sooner done by that which we shewed before in the 18. *Prop*.

20 *To find a side by knowing the three angles.*

If for the greater angle we take his complement to 180 *gr* the angles shall be turned into sides, and the sides into angles, & the operation shall be the same, as in the former *Prop*.

21 *To finde a side, by hauing the other two sides, and the angle comprehended.*

This proposition being the conuerse of the nineteenth,

 may

may be wrought accordingly; but the best way both for it and those which follow, is to resolue them into two rectangles, by letting downe a perpendicular, as was shewed in the first *Prop.*

So in the triangle *Z P S*, hauing *Z P* the complement of the latitude, and *P S* the complement of the declination, with *Z P S* the angle of the houre from the meridian, we may find *Z S* the complement of the altitude of the Sunne.

For hauing let downe the perpendicular *Z R* by the first *Prop.* we haue two triangles, *Z R P*, *Z R S*, both rectangle at *R*. Then may we find the side *P R*, either by the second, or tenth, or eleuenth *Prop*; which taken out of *P S*, leaueth the side *R S*: with this *R S* and *Z R* we may find the base *Z S* by the fourth *Prop.*

Or hauing let downe the perpendicular *S M*, we haue two rectangle triangles *S M Z*, *S M P*. Then may we find *M P*, from which if we take *Z P*, there remaineth *M Z*: but with *M Z* and *S M*, we may find the base *Z S*.

22 *To find a side, by hauing the other two sides, and one of the angles next the inquired side.*

So in the triangle *Z P S*, hauing *Z P* the complement of the latitude, and *P S* the complement of the declination, with *P Z S* the angle of the azimuth, we may finde *Z S* the complement of the altitude of the Sunne.

For hauing *Z P*, and the angle at *Z*, we may to *S Z* produced, let downe a perpendicular *P V*. Then we haue two rectangle triangles, P V Z, P V S, wherein if we find the sides V Z, V S, and take the one out of the other, there will remaine the side inquired *Z S*.

23 *To find a side, by hauing one side, and the two angles next the inquired side.*

So in the triangle A B D, hauing AB the place of the sun, and *B A D* the angle of the greatest declination, and *A D B* the

the angle of the equator with the horizon, we may find *A D* the oblique ascention.

For hauing let downe *B C* the perpendicular of declination, we haue two rectangle triangles, *A C B*, *D C* B. Then may we find *A C* the right ascention, and D C the ascentionall difference; and comparing the one with the other, there remaineth *A D*.

24 *To find a side, by hauing two angles, and the side inclosed by them.*

So in the triangle *Z P S*, hauing the angles at Z and P, with the side intercepted Z P, we may find the side P S. For hauing let downe the perpendicular P V, we haue two rectangles P V Z, P V S. Then may we find the angle V P Z, either by the seuenth, or fifteenth, or sixteenth *Prop.* which added to Z P S, maketh the angle V P S: with this V P S and P V, we may find the base PS, according to the 13 *Prop.*

25 *To find an angle by hauing the other two angles and the side inclosed by them.*

So in the triangle Z P *S*, hauing the angles at *Z* and *P*, with the side intercepted Z P, we may finde the other angle Z *S* P. For hauing let downe the perpendicular *Z R*, we haue two rectangles Z R P, Z R *S*. Then may we finde the angle P Z R by the sixteenth *Prop.* and that compared with P Z *S*, leaueth the angle R Z *S*: with this *R Z S* and *Z R* we may find the angle required *Z S R*, according to the sixth *Prop.*

26 *To finde an angle, by hauing the other two angles, and one of the sides next the inquired angle.*

So in the triangle A B D, hauing the angles at *A* and *D*, with the side A B, we may find the angle A B D. For hauing let downe the perpendicular B C, we haue two rectangles

A C B,

A C B, D C B. Then may we find the angles ABC, DBC; and take D B C out of A B C; for so there remaineth the angle required A B D.

27 *To finde an angle, by knowing two sides, and the angle contained by them.*

So in the triangle Z P S, hauing the sides Z P, P S, with the angle comprehended Z P S, we may find the angle PZS. For hauing let downe the perpendicular S M, we haue two rectangles *S M Z*, *S* M P. Then may we find the side M P, and taking Z P out of M P, there remaineth *M Z*: with this *M Z* and the perpendicular *M S*, we may finde the angle *MZ S*, by the fourteenth *Prop.* This angle M Z*S*, taken out of 180 *gr.* there remaineth P Z *S*.

28 *To find an angle by knowing the two sides next it, and one of the other angles.*

So in the triangle *Z P S*, hauing the sides *Z P* and *P S*, with the angle *P Z S*, we may find the angle Z *P S*. For hauing let downe the perpendicular *PV*, we haue two rectangles P V Z, P V S. Then may we find the angles V PZ, V P S; and taking V P *Z* out of V P S, there remaineth Z P S, which was required.

These 28 cases are all that can fall out in any sphericall triangle: if any do not presently vnderstand them, let them once more reade ouer the vse of the globes, and they shall soone become easie vnto them.

CHAP.

CHAP. VI.

Of the vse of the Meridian line in Nauigation.

THe *Meridian* line is here set on the side of the Sector, stretched forth at full length, on the same plane with the line of *lines* and *Solids*, and is diuided vnequally toward 87 *gr.* (whereof 70 *gr.* are about one halfe) in such sort as the Meridian in the cart of *Mercators* proiection. The vse of it may be

1 *To diuide a sea-chart according to* Mercators *proiection.*

If a degree of the equator on the sea-chart be equall to the hundred part of the line of *lines* in the *Sector*, the degrees of the *Meridian* vpon the *Sector*, shall giue the like degrees vpon the sea-chart: if otherwise they be vnequall, then may the meridians of the sea-chart be diuided in such sort as the line of *Meridians* is diuided on the *Sector*, by that which we shewed before in the 8 *Prop.* of the line of *lines*.

But to auoid error, I haue here set downe a Table, whereby the Meridian line may be diuided out of the degrees of the equator, supposing each degree to be subdiuided into a thousand parts. By which Table, & the vsuall Table of *Sines*, *Tangents* and *Secants*, the proportions following may be also resolued arithmetically. For the maner of diuision, let the equator (or one of the parallels if it be a particular chart) be drawne, and diuided, and crossed with parallell meridians, as in the common sea-chart: then looke into the Table, and let the distance of 40 *gr.* in the meridian, from the equator, be equall to 43 *gr.* 711 *parts* of the equator; let 50 *gr.* in the meridian from the equator, be equall to 57 *gr.* 909 *parts* of the equator; and so in the rest.

M	Gr	Par	M	Gr	Par	M	Gr	Par	M	Gr	Par	M	Gr	Par
0	0	0	3	3	001	6	6	011	9	9	037	12	12	088
		100		3	101		6	111		9	138		12	190
		200		3	201		6	212		9	239		12	293
		300		3	301		6	312		9	341		12	395
		400		3	402		6	413		9	442		12	497
		500		3	502		6	514		9	543		12	600
		600		3	602		6	614		9	645		12	702
		700		3	702		6	715		9	746		12	805
		800		3	803		6	816		9	848		12	907
		900		3	903		6	916		9	949		13	010
1	1	000	4	4	003	7	7	017	10	10	051	13	13	112
	1	100		4	103		7	118		10	152		13	215
	1	200		4	204		7	219		10	254		13	318
	1	300		4	304		7	319		10	355		13	421
	1	400		4	404		7	420		10	457		13	523
	1	500		4	504		7	521		10	559		13	626
	1	600		4	605		7	622		10	661		13	729
	1	700		4	705		7	723		10	762		13	832
	1	800		4	805		7	824		10	864		13	935
	1	900		4	906		7	925		10	966		14	038
2	2	000	5	5	006	8	8	026	11	11	068	14	14	141
	2	100		5	106		8	127		11	170		14	244
	2	200		5	207		8	228		11	272		14	347
	2	300		5	307		8	329		11	374		14	450
	2	400		5	408		8	430		11	476		14	553
	2	500		5	508		8	531		11	578		14	656
	2	601		5	609		8	632		11	680		14	760
	2	701		5	709		8	733		11	782		14	863
	2	801		5	810		8	834		11	884		14	967
	2	901		5	910		8	936		11	986		15	070
3	3	001	6	6	011	9	9	037	12	12	088	15	15	174

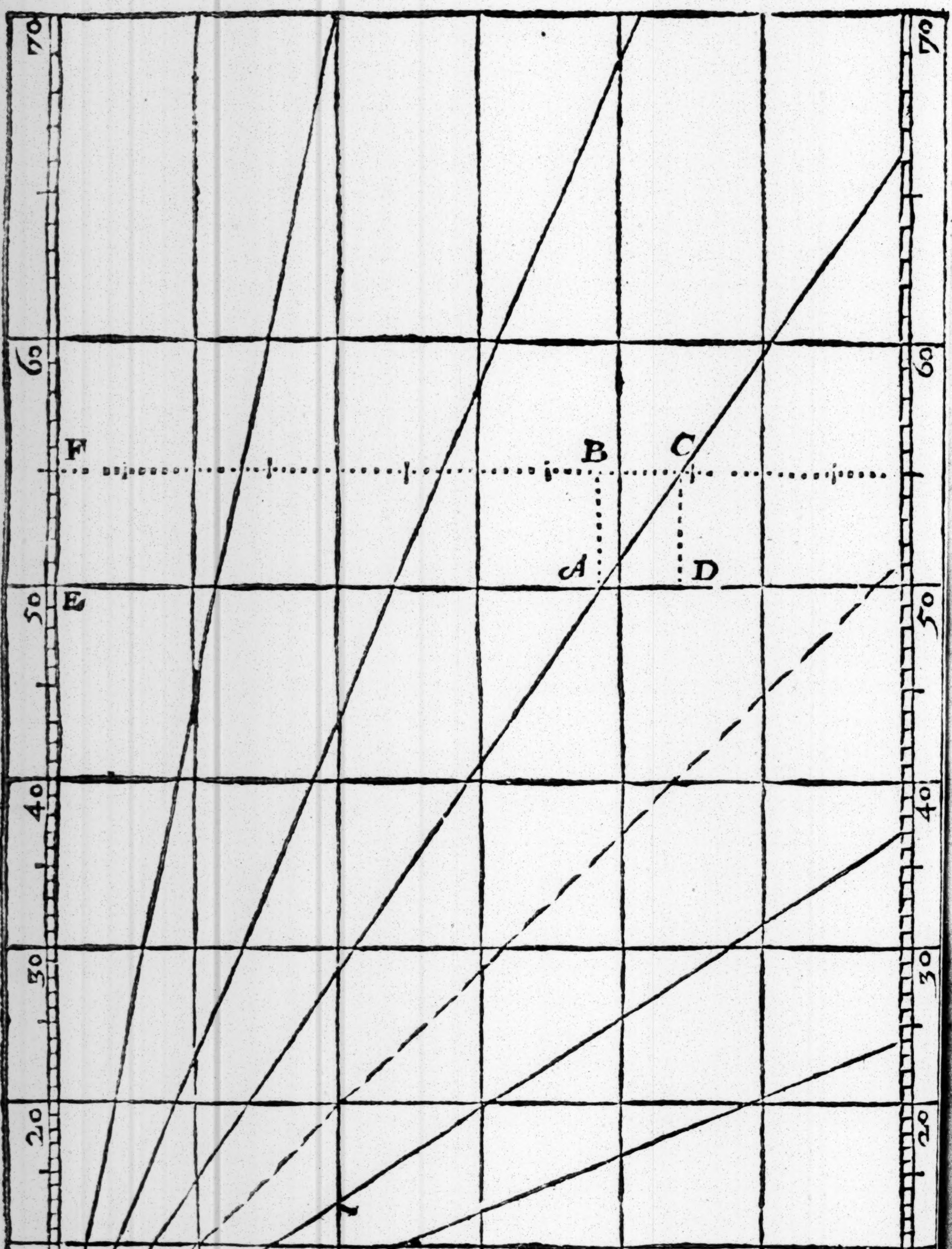
M	*Gr*	*Par*	*M*	*Gr*	*Par*	*M*	*Gr*	*Par*	*M*	*Gr*	*part*	*M*	*Gr*	*part*
15	15	174	18	18	303	21	21	486	24	24	734	27	28	058
	15	277		18	408		21	593		24	844		28	171
	15	381		18	513		21	701		24	953		28	283
	15	485		18	619		21	808		25	063		28	396
	15	588		18	724		21	915		25	173		28	508
	15	692		18	830		21	023		25	282		28	621
	15	796		18	935		22	130		25	392		28	734
	15	900		19	041		22	238		25	502		28	847
	16	004		19	146		22	345		25	613		28	959
	16	107		19	251		22	453		25	723		29	072
16	16	211	19	19	356	22	22	561	25	25	833	28	29	186
	16	316		19	463		22	669		25	943		29	299
	16	420		19	569		22	777		26	054		29	413
	16	524		19	675		22	885		26	164		29	526
	16	628		19	781		22	993		26	275		29	640
	16	732		19	887		23	101		26	386		29	753
	16	836		19	993		23	210		26	497		29	867
	16	941		20	100		23	318		26	608		29	981
	17	045		20	206		23	427		26	719		30	095
	17	150		20	312		23	535		26	830		30	300
17	17	255	20	20	419	23	23	643	26	26	941	29	30	324
	17	359		20	525		23	752		27	052		30	438
	17	464		20	632		23	861		27	164		30	553
	17	568		20	738		23	970		27	275		30	667
	17	673		20	845		24	079		27	387		30	782
	17	778		20	952		24	188		27	499		30	897
	17	883		21	059		24	297		27	610		31	012
	17	988		21	165		24	406		27	722		31	127
	18	093		21	272		24	515		27	834		31	242
	18	198		21	379		24	624		27	946		31	357
18	18	303	21	21	486	24	24	734	27	28	058	30	31	473

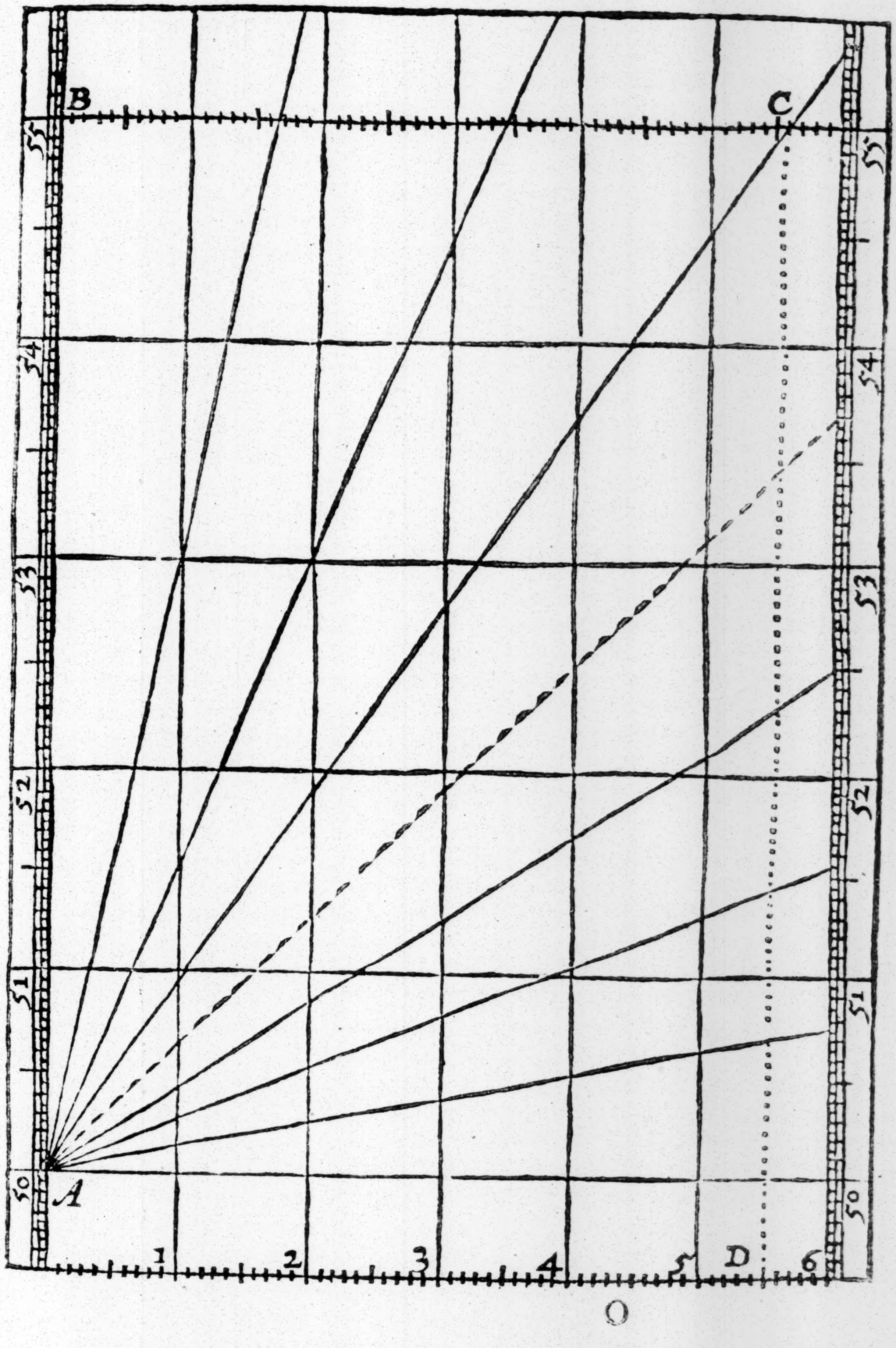
M	Gr	Par	M	Gr	Par	M	Gr	Par	M	Gr	Par	M	Gr	Par
30	31	473	33	34	992	36	38	633	39	42	415	42	46	362
	31	588		35	111		38	757		42	544		46	496
	31	704		35	231		38	880		42	673		46	631
	31	820		35	350		39	004		42	802		46	766
	31	936		35	470		39	129		42	931		46	902
	32	052		35	590		39	253		43	061		47	037
	32	168		35	710		39	377		43	191		47	173
	32	284		35	830		39	502		43	320		47	309
	32	400		35	950		39	627		43	451		47	445
	32	517		36	071		39	752		43	581		47	581
31	32	633	34	36	191	37	39	877	40	43	711	43	47	718
	32	750		36	312		40	002		43	842		47	855
	32	867		36	433		40	128		43	973		47	992
	32	984		36	554		40	253		44	104		48	129
	33	101		36	675		40	379		44	235		48	267
	33	218		36	796		40	505		44	366		48	404
	33	336		36	917		40	631		44	498		48	542
	33	453		37	039		40	757		44	630		48	681
	33	571		37	161		40	884		44	762		48	819
	33	688		37	283		41	011		44	894		48	958
32	33	806	35	37	405	38	41	137	41	45	026	44	49	097
	33	924		37	527		41	264		45	159		49	236
	34	042		37	649		41	392		45	292		49	375
	34	161		37	771		41	519		45	425		49	515
	34	279		37	894		41	646		45	558		49	655
	34	397		38	017		41	774		45	691		49	795
	34	516		38	140		41	902		45	825		49	935
	34	635		38	263		42	030		45	959		50	076
	34	754		38	386		42	158		46	093		50	217
	34	873		38	509		42	287		46	227		50	358
33	34	992	36	38	633	39	42	415	42	46	362	45	50	499

M	Gr	Par	M	Gr	Par	M	Gr	Par	M	Gr	part	M	Gr	part
45	50	499	48	54	860	51	59	481	54	64	412	57	69	711
	50	641		55	010		59	640		64	582		69	895
	50	783		55	160		59	800		64	753		70	080
	50	925		55	310		59	960		64	924		70	263
	51	068		55	460		60	120		65	096		70	449
	51	210		55	611		60	280		65	268		70	635
	51	353		55	762		60	441		65	440		70	821
	51	496		55	913		60	602		65	613		71	008
	51	639		56	065		60	763		65	786		71	195
	51	783		56	217		60	925		65	960		71	383
46	51	927	49	56	369	52	61	088	55	66	134	58	71	572
	52	071		56	522		61	250		66	308		71	761
	52	215		56	675		61	413		66	483		71	950
	52	360		56	828		61	577		66	659		72	140
	52	505		56	981		61	740		66	835		72	331
	52	650		57	135		61	904		67	011		72	522
	52	795		57	289		62	069		67	188		72	714
	52	941		57	444		62	234		67	365		72	906
	53	087		57	598		62	399		67	543		73	099
	53	233		57	754		62	564		67	721		73	292
47	53	380	50	57	909	53	62	730	56	67	900	59	73	486
	53	526		58	065		62	897		68	079		73	680
	53	673		58	221		63	063		68	258		73	875
	53	821		58	377		63	231		68	438		74	071
	53	968		58	534		63	398		68	618		74	267
	54	116		58	691		63	566		68	799		74	464
	54	264		58	848		63	734		68	981		74	661
	54	413		59	006		63	903		69	163		74	859
	54	562		59	164		64	072		69	345		75	057
	54	711		59	322		64	242		69	528		75	256
48	54	860	51	59	481	54	64	412	57	69	711	60	75	456

M	Gr	Par	M	Gr	Par	M	Gr	Par	M	Gr	Par	M	Gr.	Par
60	75	450	63	81	749	66	88	725	69	96	575	72	105	579
	75	656		81	970		88	971		96	854		105	904
	75	857		82	191		89	219		97	135		106	230
	76	059		82	413		89	467		97	418		106	558
	76	261		82	635		89	716		97	701		106	888
	76	464		82	860		89	967		97	986		107	220
	76	667		83	084		90	218		98	272		107	553
	76	871		83	310		90	470		98	560		107	888
	77	076		83	536		90	723		98	849		108	226
	77	281		83	763		90	978		99	139		108	565
61	77	487	64	83	990	67	91	232	70	99	431	73	108	906
	77	694		84	219		91	489		99	724		109	249
	77	901		84	448		91	746		100	018		109	594
	78	109		84	678		92	005		100	314		109	941
	78	317		84	909		92	264		100	612		110	290
	78	526		85	141		92	525		100	910		110	641
	78	736		85	374		92	787		101	211		110	994
	78	947		85	607		93	050		101	513		111	349
	79	158		85	842		93	314		101	816		111	707
	79	370		86	077		93	579		102	121		112	066
62	79	583	65	86	313	68	93	846	71	102	427	74	112	428
	79	796		86	550		94	113		102	735		112	792
	80	010		86	788		94	382		103	044		113	158
	80	225		87	027		94	652		103	356		113	526
	80	441		87	267		94	923		103	668		113	897
	80	657		87	508		95	195		103	983		114	270
	80	874		87	749		95	468		104	299		114	645
	81	091		87	992		95	743		104	616		115	023
	81	310		88	235		96	019		104	936		115	403
	81	529		88	480		96	296		105	257		115	786
63	81	749	66	88	725	69	96	575	72	105	579	75	116	171

M	Gr.	Par	M	Gr.	Par	M	Gr.	Par	M	Gr.	Par	M	Gr.	part
75	110	171	78	129	075	81	145	650	84	168	947	87	208	705
	116	559		129	558		146	292		169	912		210	649
	116	949		130	045		146	942		170	893		212	668
	117	342		130	536		147	600		171	891		214	745
	117	737		131	031		148	265		172	907		216	909
	118	135		131	530		148	937		173	941		219	158
	118	536		132	034		149	618		174	994		221	498
	118	939		132	542		150	307		176	067		223	938
	119	345		133	055		151	003		177	160		226	486
	119	755		133	572		151	709		178	275		229	153
76	120	166	79	134	094	82	152	423	85	179	411	88	231	950
	120	581		134	620		153	147		180	569		234	891
	121	000		135	151		153	878		181	7,2		237	991
	121	420		135	687		154	620		182	960		241	268
	121	843		136	228		155	372		184	194		244	744
	122	270		136	775		156	132		185	454		248	445
	122	700		137	326		156	903		186	743		252	402
	123	133		137	883		157	685		188	062		256	652
	123	570		138	445		158	478		189	411		261	243
	124	009		139	012		159	281		190	793		266	235
77	124	452	80	139	585	83	160	096	86	192	210	89	271	705
	124	898		140	164		160	922		193	661		277	753
	125	348		140	748		161	761		195	151		284	517
	125	801		141	339		162	612		196	680		292	191
	126	258		141	936		163	475		198	251		301	058
	126	718		142	538		164	352		199	867		311	563
	127	182		143	147		165	242		201	529		324	455
	127	649		143	763		166	146		203	240		341	166
	128	121		144	385		267	065		205	005		365	039
	128	596		145	014		167	999		206	825		408	011
78	129	075	81	145	650	84	168	947	87	208	705	90	Infinite	


F
B
C
A
D
E
10
20
30
40
50
60
70



O

If any desire to haue his chart to agree with his *Sector*, he may make each degree of longitude equall to the tenth part of the line of *lines*, and diuide the meridian of his chart out of the Sector: so shall each degree of the chart, be ten times as large as the like degree on the *Sector*, and the worke be easie from the one to the other.

2 *To find how many leagues answer to one degree of longitude in euery seuerall latitude.*

In sailing by the compasse, the course holds sometime vpon a great circle, sometime vpon a parallel to the equator; but most commonly vpon crooked lines winding towards one of the poles, which lines are well knowne by the name of *Rumbs*.

If the course hold vpon a great circle, it is either North or South, vnder some meridian, or East or West, vnder the equator. And in these cases, euery degree requires an allowance of twentie leagues, euery twentie leagues will make a degrees difference in the sailing: so that here needs no further precept then the rule of proportion in the Chapter of *lines*.

But if the course hold East or West, on any of the parallels to the equator;

As the Radius
is to twentie leagues, the measure of one degree at the equator:
So the sine of the complement of the latitude
to the measure of leagues answering to one degree in that latitude.

Wherefore I take 20 leagues out of the line of *lines*, and make it a parallell Radius, by fitting it ouer in the sines of 90 and 90: so his parallell sine taken out of the complement of the latitude, and measured in the line of *lines*, shall shew the number of leagues required.

Thus

Thus in the latitude of 18 *gr.* 12 *m.* we ſhall find 19 leagues anſwering to one degree of longitude, and 18 leagues in the latitude of 25 *gr.* 15 *m.* and as in this Table.

Gr.	1	Lg
0	0	20
18	12	19
25	15	18
31	48	17
36	52	16
41	25	15
45	34	14
49	28	13
53	8	12
56	38	11
60	0	10
63	15	9
66	25	8
69	30	7
72	32	6
75	31	5
78	28	4
81	23	3
84	15	2
87	8	1

This may be done more readily without opening the Sector, by doubling the ſine of the complement of the latitude, as may appeare in the ſame example.

It may alſo be done by the line of meridians, either vpon the Sector, or vpon the chart. For if we open a paire of compaſſes to the quantitie of one degree of longitude in the equator, and meaſure it in the meridian line, ſetting one foot as much aboue the latitude giuen, as the other falleth beneath it, ſo that the latitude may be in the middle betweene the feete of the compaſſes, the number of leagues intercepted ſhall be that which was required.

But if the courſe hold vpon any of the *rumbs*, betweene a parallell of the equator and the meridian, we are to conſider beſides the quarter of the world to which we tend, which muſt be alwayes knowne.

1 The difference of longitude at leaſt in generall.

2 The difference of latitude, and that in particular.

3 The *rumb* whereon the courſe holds.

4 The diſtance vpō the *rumb*, which is the diſtance, which we are here to conſider, and is alwayes ſomewhat greater then the like diſtance vpon a greater circle. And for theſe first I ſhew in generall this third *Prop.*

3 *To finde how many leagues do anſwer to one degree of latitude in euery ſeuerall Rumb.*

As the ſine of the complement of the *rumb* frō the meridian
is to 20 leagues the meaſure of one degree at the meridian
So the Radius
to the leagues anſwering to one degree vpon the Rumb.

Wherfore I take 20 leagues out of the line of *lines*, and make it a paralleil sine of the complement of the Rumb from the meridian; so his parallell Radius taken and measured in the line of *lines*, shall shew the number of leagues required.

Thus in the first Rumb from the meridian, we shall finde 20 *lgs* 39 *parts* answering to one degree of latitude, and 21 *lgs* 65 *parts* in the second Rumb, &c. as in this Table, where we subdiuide each league into a hundred parts, and shew besides what inclination the rumb hath to the meridian.

This may be done more readily without opening the *Sector*, by doubling the secant of the latitude, as may appeare in the same example.

It may also be done vpon the chart, if we take the distance vpon the Rumb betweene two parallels, and measure it in the meridian line, as farre aboue the greater latitude as beneath the lesser. For so the number of leagues intercepted, shall be that which was required.

This considered in generall, I shew more particularly in twelue *Prop.* following, how of these foure any two being giuen, the other two may be found, both by *Mercators* chart, and by this *Sector*.

Rumbs.	*Inclinatio to the meridian* Gr.	Mi.	*Number of leags.* Lgs	Par
	2	49	20	02
	5	37	20	10
	8	26	20	22
1	11	15	20	39
	14	4	20	62
	16	52	20	90
	19	41	21	24
2	22	30	21	65
	25	19	22	12
	28	7	22	68
	30	56	23	32
3	33	45	24	05
	36	34	24	90
	39	22	25	87
	42	11	26	99
4	45	0	28	28
	47	49	29	78
	50	37	31	52
	53	26	33	57
5	56	15	36	00
	59	4	38	90
	61	52	42	43
	64	41	36	78
6	67	30	52	26
	70	19	59	37
	73	7	68	90
	75	56	82	31
7	78	45	102	52
	81	34	136	30
	84	22	205	24
	87	11	407	60
8	90	0	*Infinita.*	

By

1 *By one latitude Rumb and distance to find the difference of latitudes.*

As the Radius
to the sine of the complement of the Rumb from the me-
So the distance vpon the Rumb, (ridian:
to the difference of latitudes.

Let the place giuen be *A* in the latitude of 50 *gr.* *C* in a greater latitude, but vnknowne, the distance vpon the Rumb being 6 *gr.* betweene them, and the Rumb the third from the meridian.

First I take 6 *gr.* for the distance vpon the Rumb, out of the line of *lines*, and make it a parallell Radius, by putting it ouer in the sines of 90 and 90. Then keeping the *Sector* at this angle, I take out the parallell sine of 56 *gr.* 15 *m.* which is the sine of the complement of the third Rumb from the meridian, and measuring it in the line of *lines*, I find it to be 5 *gr.* and such is the difference of latitude required.

Or I may take out the sine of 56 *gr.* 15 *m.* for the complement of the third Rumb from the meridian, make it a parallell Radius; then keeping the *Sector* at this angle, I take 6 *gr.* for the distance, either out of the line of *lines*, or any other scale of equall parts, or else out of the meridian line, and lay it on both sides of the *Sector* from the center, either on the line of *lines* or *sines*: so the parallell taken from the termes of this distance, and measured in the same scale wherein the distance was measured, shall shew the difference of latitude to be 5 *gr.* as before.

But in shorter distances, such as fall within the compasse of a dayes sailing, this worke will hold much better. As may appeare by comparing the worke with the Table following, where the numbers in the front do signifie the leagues; those in the side, the Rumb; and the rest in the middle, the difference of latitude.

Lgs	100		80		60		40		20	19	18	17	16	15
Rumbs	G.	M	G.	M	G.	M	G.	M	M	M	M	M	M	M
	5	0	4	0	3	0	2	0	60	57	54	51	48	45
	4	59	3	59	2	59	1	59	60	57	54	51	48	45
	4	58	3	58	2	59	1	59	60	57	54	51	48	45
	4	56	3	57	2	58	1	58	59	56	53	50	47	44
1	4	54	3	55	2	56	1	57	59	56	53	50	47	44
	4	51	3	53	2	55	1	56	58	56	52	50	47	43
	4	47	3	50	2	52	1	55	57	55	52	49	46	43
	4	42	3	46	2	49	1	53	56	54	51	48	45	42
2	4	37	3	42	2	46	1	51	55	53	50	47	44	41
	4	31	3	37	2	43	1	48	54	52	49	46	43	40
	4	25	3	32	2	39	1	46	53	50	48	45	42	39
	4	17	3	26	2	34	1	43	51	49	46	44	41	38
3	4	10	3	20	2	30	1	40	50	47	45	42	40	37
	4	1	3	13	2	25	1	36	48	46	43	41	39	36
	3	52	3	5	2	19	1	32	46	44	42	39	37	35
	3	42	2	58	2	13	1	28	44	42	40	38	36	33
4	3	32	2	50	2	7	1	25	42	40	38	36	34	32
	3	22	2	41	2	1	1	21	40	38	36	34	32	30
	3	10	2	32	1	54	1	16	38	36	34	32	30	28
	2	59	2	23	1	47	1	12	36	34	32	30	29	27
5	2	47	2	14	1	40	1	7	33	32	30	28	27	25
	2	34	2	3	1	32	1	2	31	29	28	26	25	23
	2	22	1	53	1	25	0	57	28	27	25	24	23	23
	2	8	1	43	1	17	0	52	26	24	23	22	21	19
6	1	55	1	32	1	8	0	46	23	22	21	20	18	17
	1	41	1	20	1	0	0	40	20	19	18	17	16	15
	1	27	1	9	0	52	0	35	17	16	16	15	14	13
	1	13	0	58	0	44	0	30	15	14	13	12	12	11
7	0	59	0	47	0	35	0	24	12	11	11	10	9	9
	0	44	0	36	0	26	0	18	9	8	8	7	7	7
	0	30	0	24	0	18	0	12	6	6	5	5	5	4
	0	15	0	12	0	9	0	9	3	3	3	3	2	2
8	0		0	0	0	0	0	0	0	0	0	0	0	0

14	13	12	11	10	9	8	7	6	5	4	3	2	1	Lg
M	M	M	M	M	M	M	M	M	M	M	M	M	M	Rum.
40	39	36	33	30	27	24	21	18	15	12	9	6	3	
42	39	36	33	30	27	24	21	18	15	12	9	6	3	
42	39	36	33	30	27	24	21	18	15	12	9	6	3	
42	39	36	33	30	27	24	21	18	15	12	9	6	3	
41	38	35	32	29	26	24	21	18	15	12	9	6	3	1
41	38	35	32	29	26	23	20	17	15	12	9	6	3	
40	37	34	32	29	26	23	20	17	14	11	9	6	3	
40	37	34	31	28	25	23	20	17	14	11	8	6	3	
39	36	33	31	28	25	22	19	17	14	11	8	6	3	2
38	35	33	30	27	24	22	19	16	14	11	8	5	3	
37	34	32	29	26	24	21	19	16	13	11	8	5	3	
36	33	31	28	26	23	21	18	15	13	10	8	5	3	
35	32	30	27	25	22	20	17	15	12	10	7	5	2	3
34	30	29	26	24	22	19	17	14	12	10	7	5	2	
33	30	28	26	23	21	19	16	14	12	9	7	5	2	
31	29	27	24	22	20	18	16	13	11	9	7	4	2	
30	28	25	23	21	19	17	15	13	11	8	6	4	2	4
28	26	24	22	20	18	16	14	12	10	8	6	4	2	
27	25	23	21	19	17	15	13	11	10	8	6	4	2	
25	23	21	20	18	16	14	13	11	9	7	5	4	2	
23	22	20	18	17	15	13	12	10	8	7	5	3	2	5
22	20	18	17	15	14	12	11	9	8	6	5	3	2	
20	18	17	16	14	13	11	10	8	7	6	4	3	1	
18	17	15	14	13	12	10	9	8	6	5	4	3	1	
16	15	14	13	11	10	9	8	7	5	5	3	2	1	6
14	13	12	11	10	9	8	7	6	5	4	3	2	1	
12	11	10	10	9	8	7	6	5	4	3	3	2	1	
10	9	9	8	7	7	6	5	4	4	3	2	1	[illegible]	
8	8	7	6	6	6	5	4	3	3	2	2	1	1	7
6	6	5	5	4	5	4	3	3	2	2	1	1	1	
4	4	4	3	3	3	2	2	2	1	1	1	1	0	
2	2	2	2	1	1	1	1	1	1	1	1	0	0	
0	0	0	0	0	0	0	0	0	0	0	0	0	0	8

In the Chart let a meridian *A B* be drawne through *A*, and in *A* with *A* B make an angle of the Rumb *B A C*. Then open the compasses, according to the latitude of the places, to *E F* the quantitie of *6 gr.* in the meridian, transferring them into the Rumb from *A* to *C*, and through *C* draw the parallell *B C*, crossing the meridian *A B* in *B*: so the degrees in the meridian from *A* to *B*, shall shew the difference of latitude to be *5 gr.*

2 *By the Rumb and both latitudes to find the distance vpon the Rumb.*

As the sine of the complement of the Rumb from the meridian,
is to the Radius:
So the difference of latitudes,
to the distance vpon the Rumb.

As if the places giuen were *A* in the latitude of *50 gr.* *C* in the latitude of *55 gr.* and the Rumb the third from the meridian.

Here I may take *5 gr.* for the difference of latitude out of the line of *lines*, and put it ouer in the sine of *56 gr. 15 m.* for the complement of the third Rumb from the meridian. Then keeping the *Sector* at this angle, I take out the parallell Radius, and measuring it in the line of *lines*, I find it to be *6 gr.* and such is the distance vpon the Rumb, which was required.

Or I may take the laterall Radius, and make it a parallell sine of *56 gr. 15 m.* the complement of the Rumb from the meridian: then keeping the Sector at this angle, I take *5 gr.* for the difference of latitude, either out of the line of *lines*, or out of some other scale of equall parts, and lay it on both sides of the *Sector* from the center, either on the line of *lines* or of *sines*. so the parallell taken from the termes of this difference, and measured in the same scale with the difference, shall shew the distance vpon the Rumb to be *6 gr.* or *120* leagues.

Or

Or keeping the *Sector* at this angle, I may take the difference betweene 50 *gr.* and 55 *gr.* out of the *Meridian* line, and measuring it in the equator, I shal find it to be equall to 8 *gr.* 22 *p.* of the equator. Wherefore I take the parallell betweene 822 and 822 out of the line of *lines*, and measuring it in the line of *lines* I shall find it to be 989; which shewes that according to this proiection, the distance vpon this third Rumb, answerable to the former distance of latitudes, will be equall to 9 *gr.* 89 *p.* of the equator.

Or the Sector remaining at this angle, I may take the difference betweene 50 *gr.* and 55 *gr.* out of the *Meridian* line, and lay it from the center on both sides of the *Sector*, either on the line of *lines* or of *sines*: so the parallell taken from the termes of this difference, shall be the very line of distance required, the same with *A C* or *E F* vpon the chart; which may serue for the better pricking downe of the distance vpon the Rumb, without taking it forth of the *Meridian* line, as in the former *Prop.*

Or if the Rumb fall nearer to the equator, that the laterall Radius cannot be fitted ouer in it, this proposition may be wrought by parallell entrance.

For if I first take out the sine of 56 *gr.* 15 *m.* and make it a parallell Radius, by fitting it ouer in the sines of 90 and 90, or in the ends of the lines of *lines*, and then take 5 *gr.* for the difference of latitudes out of the line of *lines*, and carrie it parallell to the former, I shall find it to crosse both lines of *lines* in the points of 6: and so it giues the same distance as before.

Or if the distance be small, it may be found by the former Table. For the Rumb being found in the side of the Table, and the difference of latitude in the same line; the top of the columne wherein the difference of latitude was found, shall giue the number of leagues in the distance required.

Or we may finde this distance in the Table of Rumbs in the fift *Prop.* following. For according to the example looke into the Table of the third Rumb for 5 *gr.* of latitude, and there we shall finde 6 *gr.* 01 *parts* vnder the title of distance.

So if the difference of latitude vpon the ſame Rumb were 50 *gr.* the diſtance would be *60 gr. 13 parts.* If the difference of latitude vpon the ſame Rumb were onely ½ of a degree, the diſtance would be onely *60 parts*, ſuch as 100 doe make a degree.

In the chart let a Meridian *A B* be drawne through *A*, and parallels of latitude through *A* and *C*; & then in *A* with *A B* make an angle of the Rumb *B A C*: ſo the diſtance taken from *A* to *C*, and meaſured in the Meridian line, according to the latitude of the places, ſhall be found to be *6 gr.* or 120 leagues. And ſuch is the diſtance required.

3 *By the diſtance and both latitudes to find the Rumb.*

As the diſtance vpon the Rumb,
to the difference of latitudes:
So is the Radius
to the ſine of the complement of the Rumb from the Meridian.

As if the places giuen were *A* in the latitude of 50 *gr.* *C* in the latitude of *55 gr.* the diſtance betweene them being *6 gr.* vpon the Rumb. Firſt I take *6 gr.* for the diſtance vpon the Rumb, and lay it on both ſides of the *Sector* from the center; then out of the ſame ſcale I take *5 gr.* for the difference of latitude, and to it open the *Sector* in the termes of the former diſtance: ſo the parallell Radius taken and meaſured in the *ſines*, doth giue *56 gr. 15 m.* the complement whereof 33 *gr. 45 m.* is the angle of the Rumbs inclination to the Meridian, which was required.

In the chart let a meridian *A B* be drawne through *A*, and parallels of latitude both through *A* and *C*; then open the compaſſes according to the latitude of the places to *E F* the quantitie of *6 gr.* in the meridian, and ſetting one foote in *A*, turne the other till it croſſe the parallell *B C* in *C*, and draw the right line *A C*: ſo the angle *B A C* ſhall ſhew the inclination of the Rumb to the Meridian to be 33 *gr. 45 m.* as before.

These

These three last *Prop.* depend one on the other, and may be wrought as truly by the common sea-chart as by this of *Mercators* proiection: and therefore in working them by the *Sector*, the distance and the difference of latitudes may as well or better be taken out of the line of *lines* (which here representeth the equator) or any other line of equall parts, as out of the inlarged degrees in the *meridian* line. But in the propositions following, the difference of longitude must be taken out of the equator; the difference of latitudes and distance vpon the Rumb, must alwayes be taken out of the *meridian* line; which I therefore call the proper difference, and proper distance.

4 *By the longitude and latitude of two places to find the Rumb.*

As if the places giuen were *A* in the latitude of 50 *gr.* C in the latitude of 55 *gr.* and the difference of longitude betweene them were 5 *gr.* 30 *m.*

In the chart let meridians and parallels be drawn through *A* and *C*, and a straight line for the Rumb from *A* to *C*; then by that we shewed *Cap.* 2. *Prop.* 9. inquire the quantitie of the angle *B A C*, and it shall be found to be 33 *gr.* 45 *m.* which is the third Rumb from the Meridian. Wherefore the proportion holds for the *Sector*,

As *A B* the proper difference of latitude,
is to *B C* the difference of longitude:
So *A B* as Radius,
to *B C* the tangent of the Rumb from the Meridian.

According to this I take the proper difference of latitude from 50 *gr.* to 55 *gr.* out of the line of *meridians*, and lay it on both sides of the *Sector* from the center; then I take the difference of longitude 5 *gr.* ½ out of the line of *lines*, and to it open the *Sector* in the termes of the former difference of latitudes: so the parallell Radius taken from betweene 90 and 90 and measured in the greater *tangent* on the side of the *Sector*,

tor, doth giue 33 *gr*. 45 *m*. for the Rumb required.

But if the Rumb fall nearer to the equator;

As *A* D the difference of longitudes,
is to *D C* the proper difference of latitudes:
So *A D* as Radius,
to *D C* the tangent of the rumb from the equator.

According to this I take the former difference of latitudes from 50 *gr*. to 55 *gr*. out of the line of *Meridians*, and to it open the *Sector* in the termes of the difference of longitude reckoned in the line of *lines* from the center: so the parallell Radius taken and measured in the *tangent*, doth giue 56 *gr*. 15 *m*. for the rumb from the equator; which is the complement to the former 33 *gr*. 45 *m*: and so both wayes it is found to be the third rumb from the Meridian.

But if this rumb were to be found in the common sea-chart, it should seeme to be aboue 47 *gr*. which is more then the fourth rumb from the meridian.

5 *By the Rumb and both latitudes to find the difference of longitude.*

As if the places giuen were *A* in the latitude of 50 *gr*. and *C* in the latitude of 55 *gr*. and the rumb the third from the meridian.

In the chart, let a meridian be drawne through *A*, and a parallell of latitude through *C*; then in *A* with *A B* make the angle of the rumb from the meridian *B A C*, (as was shewed *Cap*. 2. *Prop*. 10.) So the degrees in the parallell betweene B and *C*, shall be found to be 5 *gr*. $\frac{1}{3}$, the difference of longitude which was required. Wherefore the proportion holds for the *Sector*,

As *A B* the Radius,
to B C the tangent of the rumb from the meridian:
So *A B* as proper difference of the latitudes,
to *B C* the difference of longitude.

According

According to this we may take the tangent of the Rumb which is here 33 *gr.*45 *m.*from the meridian, out of the greater *tangent* on the side of the *Sector*; and putting it ouer betweene 90 and 90, make it a Radius: then keeping the *Sector* at this angle, take the proper difference of latitudes from 50 *gr.*to 55 *gr.*out of the line of *Meridians*, and lay it on both sides of the *Sector* from the center: so the parallel taken from the termes of this difference, and measured in the line of *lines*, shall shew the difference of longitude to be 5 *gr.* $\frac{1}{2}$.

Or if the Rumb fall nearer the equator.

As *D C* the tangent of the *Rumb* from the equator,
to *A D* the *Radius*:
So *D C* as proper difference of the latitudes,
to *A D* the difference of longitude.

According to this we may best work by parallell entrance, first taking 56 *gr.*15 *m.*for the angle of the *Rumb* from the equator, out of the greater *tangent*, and make it a parallell *Radius*: then take the proper difference of latitudes out of the line of *meridians*, and carrie it parallell to the former: so we shall find it to crosse the line of *lines* in 5 *gr.* $\frac{1}{2}$. And this is the difference of longitude required, the same as before.

But if this difference were to be found by the common sea-chart, it should seeme to be only 3 *gr.*20 *m.*which is more then 2 *gr.*lesse then the truth. And yet this error would be greater, if either the latitude be greater, or the *Rumb* fall nearer the equator: as may appeare by comparing the common sea-chart with the Tables following.

[illegible]					North and by East, South and by East,					North and by West, South and by West.				
Lat.	Long.		Dist.		Lat.	Long.		Dist.		Lat.	Long.		Dist.	
Gr.	Gr.	P.	Gr.	P.	Gr.	Gr.	P.	Gr.	P.	Gr.	Gr.	P.	Gr.	P.
0		0		0	30	6	26	30	5	60	15	01	61	18
1		20	1	02	31	6	49	31	61	61	15	41	62	20
2		40	2	04	32	6	72	32	63	62	15	83	63	21
3		60	3	06	33	6	96	33	65	63	16	26	64	23
4		80	4	08	34	7	20	34	67	64	16	71	65	25
5	1	00	5	10	35	7	44	35	69	65	17	17	66	27
6	1	20	6	12	36	7	68	36	71	66	17	65	67	29
7	1	40	7	14	37	7	92	37	73	67	18	15	68	31
8	1	60	8	16	38	8	17	38	75	68	18	67	69	33
9	1	80	9	18	39	8	43	39	77	69	19	21	70	35
10	2	00	10	20	40	8	70	40	78	70	19	78	71	37
11	2	20	11	22	41	8	96	41	80	71	20	37	72	39
12	2	40	12	24	42	9	22	42	82	72	21	00	73	41
13	2	61	13	25	43	9	50	43	84	73	21	66	74	43
14	2	81	14	27	44	9	76	44	86	74	22	36	75	45
15	3	02	15	29	45	10	04	45	88	75	23	10	76	47
16	3	22	16	31	46	10	33	46	90	76	23	90	77	49
17	3	42	17	33	47	10	62	47	92	77	24	75	78	51
18	3	64	18	35	48	10	91	48	94	78	25	67	79	53
19	3	85	19	37	49	11	21	49	96	79	26	67	80	55
20	4	06	20	39	50	11	52	50	98	80	27	76	81	57
21	4	27	21	41	51	11	83	52	0	81	28	97	82	59
22	4	49	22	43	52	12	15	53	2	82	30	32	83	61
23	4	70	23	45	53	12	47	54	4	83	31	84	84	63
24	4	92	24	47	54	12	81	55	6	84	33	61	85	62
25	5	14	25	49	55	13	16	56	8	85	35	69	86	67
26	5	36	26	51	56	13	50	57	10	86	38	24	87	69
27	5	58	27	53	57	13	86	58	12	87	41	52	88	71
28	5	80	28	55	58	14	23	59	14	88	46	15	89	73
29	6	03	29	57	59	14	62	60	16	89	54	06	90	75
30	6	26	30	59	60	15	01	61	18	90				

The second Rumbe from the Meridian.					North North-east. South South-east.					North North-west South South-west				
La	Long.		Dist.		La	Long		Dist.		La	Long.		Dist.	
Gr	Gr.	P	Gr.	P	Gr	Gr.	P	Gr.	P	Gr	Gr.	P.	Gr.	P.
0		0		0	30	13	03	32	47	60	31	25	64	94
1	0	42	1	08	31	13	51	33	5[illegible]	61	32	09	66	03
2	0	83	2	16	32	14	00	34	64	62	32	96	67	11
3	1	24	3	25	33	14	49	35	72	63	33	86	68	19
4	1	65	4	33	34	15	00	36	80	64	34	79	69	27
5	2	07	5	41	35	15	50	37	88	65	35	7[illegible]	70	35
6	2	49	6	49	36	16	00	38	97	66	36	75	71	44
7	2	91	7	57	37	16	51	40	05	67	37	80	72	52
8	3	32	8	66	38	17	03	41	13	68	38	88	73	60
9	3	74	9	74	39	17	56	42	21	69	40	00	74	68
10	4	16	10	82	40	18	10	43	30	70	41	19	75	77
11	4	59	11	90	41	18	65	44	38	71	42	43	76	85
12	5	01	12	99	42	19	20	45	46	72	43	74	77	93
13	5	42	14	07	43	19	76	46	54	73	45	11	79	01
14	5	85	15	15	44	20	33	47	62	74	46	57	80	10
15	6	28	16	23	45	20	92	48	71	75	48	12	81	18
16	6	71	17	32	46	21	50	49	79	76	49	78	82	26
17	7	14	18	40	47	22	11	50	87	77	51	55	83	34
18	7	58	19	48	48	22	72	51	95	78	53	46	84	42
19	8	01	20	56	49	23	35	53	03	79	55	54	85	51
20	8	45	21	65	50	23	98	54	12	80	57	82	86	59
21	8	90	22	73	51	24	63	55	20	81	60	33	87	67
22	9	34	23	81	52	25	30	56	28	82	63	13	88	76
23	9	79	24	89	53	25	98	57	37	83	66	22	89	84
24	10	24	25	98	54	26	68	58	45	84	69	99	90	92
25	10	70	27	06	55	27	39	59	53	85	74	23	92	00
26	11	16	28	14	56	28	12	60	61	86	79	63	93	09
27	11	62	29	22	57	28	87	61	70	87	86	46	94	17
28	12	08	30	31	58	29	64	62	78	88	96	10	95	25
29	12	55	31	39	59	30	44	63	86	89	112	57	96	33
30	13	03	32	47	60	31	25	64	94	90				

The third Rumbe from the Meridian.					North-east by North, South-east by South,					North-west by North, South-west by South.				
La	Long.		Dist.		La	Long.		Dist.		La	Long.		Dist.	
Gr	Gr.	P.	Gr.	P.	Gr	Gr.	P.	Gr.	P.	Gr	Gr.	P.	Gr.	P
0		0		0	30	21	03	36	08	60	50	42	72	16
1	0	66	1	20	31	21	80	37	28	61	51	78	73	36
2	1	33	2	40	32	22	58	38	49	62	53	18	74	56
3	2	00	3	61	33	23	38	39	69	63	54	63	75	77
4	2	67	4	81	34	24	18	40	89	64	56	12	76	97
5	3	34	6	01	35	25	00	42	09	65	57	68	78	17
6	4	01	7	22	36	25	82	43	30	66	59	29	79	37
7	4	68	8	42	37	26	64	44	50	67	60	96	80	58
8	5	36	9	62	38	27	48	45	70	68	62	71	81	78
9	6	03	10	82	39	28	34	46	90	69	64	53	82	98
10	6	71	12	03	40	29	21	48	11	70	66	44	84	19
11	7	39	13	23	41	30	09	49	31	71	68	45	85	39
12	8	07	14	43	42	30	98	50	51	72	70	55	86	59
13	8	76	15	64	43	31	88	51	71	73	72	77	87	79
14	9	44	16	84	44	32	80	52	92	74	75	12	89	00
15	10	13	18	04	45	33	74	54	12	75	77	62	90	20
16	10	83	19	24	46	34	69	55	32	76	80	30	91	40
17	11	53	20	45	47	35	67	56	52	77	83	15	92	61
18	12	23	21	65	48	36	66	57	73	78	86	25	93	81
19	12	93	22	85	49	37	67	58	93	79	89	60	95	01
20	13	64	24	05	50	38	69	60	13	80	93	27	96	22
21	14	35	25	26	51	39	74	61	33	81	97	32	97	42
22	15	07	26	46	52	40	82	62	54	82	101	85	98	62
23	15	80	27	66	53	41	91	63	74	83	106	97	99	82
24	16	53	28	86	54	43	03	64	94	84	112	90	101	03
25	17	26	30	07	55	44	19	66	1[illegible]	85	119	90	102	23
26	18	00	31	27	56	45	37	67	35	86	128	45	103	43
27	18	75	32	47	57	46	58	68	55	87	139	47	104	64
28	19	50	33	67	58	47	82	69	75	88	155	00	105	84
29	20	26	34	88	59	49	11	70	96	[illegible]9	181	58	107	04
30	21	03	36	08	60	50	42	72	16	90				

The eight Rumbe of East and West, with the Longitude answering to one degree of distance, and the distance belonging to one degree of Longitude.

La	Long.		Dist.		La	Long.		Dist.		La	Long.		Dist.	
Gr	Gr.	P.	Parts.		Gr	Gr.	P.	Parts.		Gr	Gr.	P.	Parts.	
0		0	100	00	30	1	25	86	60	60	2	00	50	00
1	1	00	99	98	31	1	17	85	71	61	2	06	48	48
2	1	00	99	94	32	1	18	84	80	62	2	13	46	94
3	1	00	99	86	33	1	19	83	86	63	2	20	45	40
4	1	00	99	75	34	1	21	82	90	64	2	28	43	83
5	1	00	99	62	35	1	22	81	91	65	2	37	42	26
6	1	01	99	45	36	1	24	80	90	66	2	46	40	67
7	1	01	99	25	37	1	25	79	86	67	2	56	39	07
8	1	01	99	02	38	1	27	78	80	68	2	67	37	46
9	1	01	98	76	39	1	29	77	71	69	2	79	35	83
10	1	02	98	48	40	1	31	76	60	70	2	92	34	20
11	1	02	98	16	41	1	33	75	47	71	3	07	32	55
12	1	02	97	81	42	1	35	74	31	72	3	24	30	90
13	1	03	97	43	43	1	37	73	13	73	3	42	29	23
14	1	03	97	03	44	1	39	71	93	74	3	63	27	56
15	1	03	96	59	45	1	41	70	71	75	3	86	25	88
16	1	04	96	12	46	1	44	69	46	76	4	13	24	19
17	1	04	95	63	47	1	47	68	20	77	4	44	22	49
18	1	05	95	10	48	1	49	66	91	78	4	81	20	79
19	1	06	94	55	49	1	52	65	60	79	5	24	19	08
20	1	06	93	97	50	1	55	64	28	80	5	76	17	36
21	1	07	93	35	51	1	59	62	93	81	6	39	15	64
22	1	08	92	72	52	1	62	61	56	82	7	18	13	91
23	1	09	92	05	53	1	66	60	18	83	8	20	12	18
24	1	09	91	35	54	1	70	58	77	84	9	57	10	45
25	1	10	90	63	55	1	74	57	35	85	11	47	8	71
26	1	11	89	88	56	1	79	55	92	86	14	33	6	97
27	1	12	89	10	57	1	84	54	46	87	19	11	5	23
28	1	13	88	29	58	1	89	52	99	88	28	65	3	49
29	1	14	87	46	59	1	94	51	50	89	57	30	1	74
30	1	15	86	60	60	2	00	50	00	90				0

These tables are calculated for each of the Rumbs.

The first seuen haue three columnes, and of them the first containeth the degrees of Latitude, from the Equinoctiall to the Pole: the second doth giue the difference of Longitude; and the third the distance, both of them belonging to that Rumb and latitude.

As in the Table of the third Rumb; at the *latitude* of 50 *Gr.* I find vnder the title of *Longitude* 38 *Gr.* 69 *parts*, and vnder the title of *Distance* 60 *Gr.* 13 *parts*. This sheweth that if the course held constantly on the third Rumb from the Equinoctiall to the Latitude of 50 *Gr.* the difference of Longitude would be 38 *Gr.* 69 *parts* of a 100, and the distance vpon the Rumbe 60 *Gr.* 13 *parts*. For here I reckon the distance by degrees, rather then by leagues or miles, and subdiuide each degree into 100 parts, rather then into 60 minutes, for the more ease in calculation, and withall to make the calculation to agree the better, both with this, and my *Crosse staffe*, and other instruments.

The vse of these Tables, for the finding of the difference of Longitude, is this. Turne to the table of the *Rumb*, and there see what longitude belongeth to either latitude, then take the one longitude out of the other, the remainder will be the difference of longitude required.

As in the former example, where the places giuen were *A*, in the latitude of 50 *Gr.* *C* in the latitude of 55 *Gr.* and the *Rumb* the third from the meridian: I looke into the table of the third *Rumb* and there find,

Latitude 50 *gr.*	Longitude	38 *gr.*	69 *parts.*
Latitude 55.	Longitude	44.	19.
Therefore the diff. of	Longitude	5	50

There is another vse of these tables, for the describing of the *Rumbs* both on the *Globe*, and all sorts of *Charts*. For hauing drawne the circles of longitude and latitude, and finding by the tables, the difference of longitude belonging to each *Rumb* and latitude: If we make a prick in the chart, at

euery

euery degree of latitude, according to that difference of longitude, and draw lines through those prickes, so as they make no angles, the lines so drawne shall be the *Rumbs* required.

The vse of the eight *Rumb* is something different from the rest. For there being here no change of latitude, I haue set to each latitude, the difference of longitude, belonging to one degree of distance, and the distance belonging to one degree of longitude.

As if two places shall be 20 leagues, or one degree distant one from the other, in the latitude of **50** *gr.* the difference of longitude betweene them will be **1** *gr.* **55** *parts.* But if they differ one degree in longitude, the distance betweene them will be onely 64 parts, which fall short of 13 leagues, or at the most 6428 parts, such as 10000 do make a degree.

6 By the difference of longitude, Rumb, and one latitude, to find the other latitude.

As if the places giuen were *A*, in the latitude of 50 *gr.* *C* in a greater latitude but vnknowne, the difference of longitude 5 *gr.* ½, and the Rumb the third from the Meridian.

In the chart let *A B*, D *C*, meridians, be drawne through *A* and *C*, according to the difference of longitude, one 5 *gr.* ½ from the other; and a parallell of latitude through *A*, crossing the meridian C D in D: then in *A*, with *A B*, make an angle of the Rumb *B A C*: so the degrees in the meridian betweene D and *C*, shall be found to be 5 *gr.* the proper difference of latitude which was required. Wherefore the proportion holds for the *Sector*,

As A D the Radius,
  to DC the tangent of the Rumb from the equator:
So A D as difference of longitude,
  to DC the proper difference of latitude.

According to this, I take 56 *gr.* 15 *m.* for the angle of the Rumb from the equator, out of the greater *Tangent*, and make

make it a parallell Radius. Then I reckon 5 *gr.* ½ in the line of *lines* from the center, for the difference of longitude. So the parallell taken from the termes of this difference, and measured in the line of *meridians*, shal reach from 50 *gr.* the latitude giuen, to 55 *gr.* which is the latitude required.

Or if the Rumb fall nearer to the meridian.

> As *BC* the tangent of the Rumb from the meridian,
> is to *AB* the Radius:
> So *BC* as difference of longitude,
> to *AD* the proper difference of latitude.

According to this we may best work by parallel entrance; first take 33 *gr.* 45 *m.* for the angle of the Rumb from the meridian, out of the greater *Tangent*, and make it a parallell Radius; then take 5 *gr.* ½ for the difference of longitude out of the line of *lines*, and carrie it parallell to the former, till the feete of the compasses stay in like points: so the line between the center and the place of this stay, being taken and measured in the line of *meridians* from 50 *gr.* forward, shall shew the latitude required to be 55 *gr.* as in the former way.

The like may be found by the tables of Rumbs. For in the table of the third Rumb, at the latitude of 50 *gr.* I finde the longitude of 38 *gr.* 69 *p*; to this if I adde 5 *gr.* 50 *p.* for the difference of longitude giuen, the compound longitude will be 44 *gr.* 19 *p.* and this answers to the latitude of 55 *gr.*

But if this difference of latitude were to be found by the common sea-chart, it should seeme to be 8 *gr.* 13 *m*; and so the second latitude should be 58 *gr.* 13 *m.* which is aboue 3 *gr.* more then the truth.

7 *By one latitude, rumb, and distance, to find the difference of longitude.*

As if the places giuen were *A* in the latitude of 50 *gr.* *C* in a greater latitude but vnknowne, the distance vpon the Rumb being 6 *gr.* betweene them, and the Rumb the third from the meridian.

In

In the chart, let a meridian *A B*, and a parallell A D be drawne through *A*; and in *A*, with A B, make an angle BAC for the Rumb from the meridian; then open the compasses according to the latitude of the places to *E F*, the quantitie of *6 gr.* in the meridian, transferring them into the Rumb from *A* to *C*, and through *C* draw another meridian D C, crossing the parallell drawne through *A* in D: so the degrees intercepted in the parallell from *A* to D, shall shew the difference of longitude required to be about 5 *gr.* ½. Wherefore the proportion holds for the Sector.

As *A C* the Radius,
is to AD, equall to B C, the sine of the Rumb from the (meridian:
So *A C* as proper distance vpon the *Rumb*,
to A D the difference of longitude.

According to this I take the sine of 33 *gr.* 45 *m.* for the angle of the *Rumb* from the meridian, and make it a parallell Radius; then keeping the *Sector* at this angle, I take *6 gr.* for the distance out of the *meridian* line, according to the estimated latitudes of both places, and lay it on both sides of the *Sector* from the center: so the parallell taken from the termes of this distance, and measured in the lines of *lines*, shall shew the difference of longitude to be about 5. *gr.* ½.

In this, and some of the *Prop.* following, where there is but one latitude knowne, there may be sometimes an error of a minute or two, in the estimation of the proper distance, yet it may be rectified at a second operation.

This proposition may also be wrought by the Tables of *Rumbs*. For according to the example, in the Table of the third *Rumb*, at the latitude of 50 *gr.* I find the longitude of 38 *gr.* 69 *p.* and the distance of 60 *gr.* 13 *p.* to this I adde *6 gr.* for the distance giuen; so the compound distance will be *66 gr.* 13 *p.* and this answers to the longitude of 44 *gr.* 19 *p*; then if I take the one longitude out of the other, the difference will be 5 *gr.* 50 *p.* as before.

But if this difference were to be found by the common sea-chart, it should seeme to be onely 3 *gr.* 20 *m.* which is

more then 2 *gr.* lesse then the truth.

8 *By one latitude, Rumb, and difference of longitudes, to find the distance.*

As if the places giuen were *A*, in the latitude of 50 *gr.* *C* in a greater latitude but vnknowne, the difference of longitude betweene them being 5 *gr.* $\frac{1}{2}$, and the Rumb the third from the meridian.

In the chart let A B, D C, meridians be drawne through *A* and *C*, according to the difference of longitude, and a parallell of latitude through *A*, crossing the meridian DC in D; then in *A*, with A B, make an angle of the Rumb BAC: so the distance on the Rumb from *A* to *C* taken and measured in the *meridian*, according to the estimated latitude of the places, shall be found to be 6 *gr.* Wherefore the proportion holds for the *Sector.*

As A D, equall to BC, the sine of the Rumb from the meridian,
is to *A C* the Radius:
So A D as difference of longitudes,
to *A C* the proper distance vpon the Rumb.

According to this, I take the laterall Radius, and make it a parallell sine of 33 *gr.* 45 *m.* which is here the angle of the Rumb from the meridian; then I reckon 5 *gr.* $\frac{1}{2}$ in the lines of *lines* from the center, for the difference of longitude: so the parallell taken from the termes of this difference, and measured in the line of *meridians*, according to the latitudes of the places, shall there shew the distance required to be about 6 *gr.* which are 120 leagues.

Or if the Rumb fall nearer to the meridian, that the lateral Radius cannot be fitted ouer in his sine, this *Prop.* must be wrought by parallell entrance, and so also it giues the same distance as before.

Or we may find this distance by the Table of Rumbs. For in the table of the third Rumb, at the latitude of 50 *gr.* I find the longitude of 38 *gr.* 69 *p.* and the distance of 60 *gr.* 13 *p.*

To

To this longitude here found, I adde 5 *gr.* 50 *p.* for the difference of longitude giuen: so the compound longitude will be 44 *gr.* 19 *p.* and this answers to the distance of 66 *gr.* 15 *p.* Then if I take the one distance out of the other, the remainder will be 6 *gr.* 02 *p.* for the distance required.

But if this distance were to be measured on the common sea-chart, it should seeme to be almost 10 *gr.* or at the least 197 leagues, aboue 77 leagues more then the truth.

9 *By one latitude, distance, and difference of longitudes, to find the Rumb.*

As if the places giuen were *A*, in the latitude of 50 *gr.* C in a greater latitude but vnknowne, the difference of longitude betweene them being 5 *gr.* $\frac{1}{2}$, and the distance 6 *gr.* vpon the *Rumb*.

In the chart let AB, DC, meridians, be drawne through *A* and *C*, and a parallell of latitude through *A*; then open the compasses according to the latitudes of the places, to *E F* the quantitie of 6 *gr.* in the ***meridian***, and setting the one foote in *A*, the other foote shall crosse the other meridian in C; and if we draw the right line *A C*, the angle BAC shall shew the inclination of the *Rumb* to the meridian to be about 33 *gr.* 45 *m.* Wherefore the proportion holds for the *Sector*.

As *A C* the proper distance vpon the *Rumb*,
is to A D the difference of longitude:
So *A C* as *Radius*,
to AD, equall to B C, the sine of the *Rumb* from the meridian.

According to this, I take the proper distance 6 *gr.* out of the line of ***meridians***, and lay it on both sides of the *Sector* from the center; then I take the difference of longitude 5 *gr.* $\frac{1}{2}$ out of the line of ***lines***, and to it open the *Sector* in the terms of the former distance: so the parallell *Radius* taken from betweene 90 and 90, and measured in the ***sines***, doth giue about 33 *gr.* 45 *m.* for the *Rumb* required.

But if this *Rumb* were to be found by the common sea-

chart, it should seeme to be aboue *66 gr.* and so almost the sixt *Rumb* from the meridian.

10 *By the longitude and latitude of two places, to find their distance vpon the Rumb.*

Let the *Sector* be opened in the lines of *lines*, vnto a right angle (as was shewed before *Cap. 2. Prop 7;*) then take out the proper difference of latitude, and lay it on the one line, and the difference of longitude, and lay it on the other line, so as they may both meete in the center, marking how far they extend. For the line taken from the termes of their extension, and measured in the *meridian*, according to their latitudes, shall shew the distance required.

So if the places giuen were *A* and *C*, *A* in the latitude of 50 *gr.* *C* in the latitude of 55 *gr.* the proper difference of latitude shall be the line *A B*, and let *B C* the difference of longitude be 5 *gr.* ½, we shall find that *A C* the distance vpon the Rumb is about 6 *gr.* which make 120 leagues.

For in the chart, let an occult meridian be drawne through *A*, and a parallell of latitude through *C*, crossing the former meridian in *B*, and a right line for the Rumb from *A* to *C*, so haue we a rectangle triangle *A B C*, whose base *A C*, taken and measured in the meridian from *E* below 50 *gr.* to *F*, as much aboue 55 *gr.* doth containe the quantitie of 6 *gr.*

In the same maner the *Sector* being opened to a right angle in the lines of *lines*: if we take the difference of latitude out of the line of *meridians*, in his proper place from 50 *gr.* to 55 *gr.* and place it on one of the sides from the center, to resemble *A B*, then reckon the difference of longitude on the other perpendicular line from the center to 5 *gr.* ½, in stead of *B C*, we shall haue the like rectangle triangle on the *Sector*, to that which we had before on the chart; and if we take out the base of it, and measure it in the line of *meridians* from below 50 *gr.* to as much aboue 55 *gr.* we shall finde as before, that it containeth about 6 *gr.* or 120 leagues.

But if this distance were to be measured on the common sea-

sea-chart, it should seeme to be almost 7 *gr.* $\frac{1}{4}$, or 145 leagues; which is 25 leagues more then the truth.

11 *By the latitude of two places, and the distance vpon the Rumb, to find the difference of longitude.*

Let the *Sector* be opened in the lines of *lines* to a right angle, then take out the proper difference of latitudes, and lay it on one of the lines from the center, then take the proper distance with a paire of compasses, and setting one foote in the termes of the difference, turne the other foote to the other line of the *Sector*, and it shall there shew the difference of longitude required.

So if the places giuen were *A*, in the latitude of 50 *gr.* *C* in the latitude of 55 *gr.* with 6 *gr.* of distance one from another, we shall find their difference of longitude to be about 5 *gr.* $\frac{1}{2}$.

For in the chart let a meridian *A B* be drawne for the one, and *B C*, *A D*, parallels of latitude for them both. Then open the compasses according to the latitude of the places, to *E F* the quantitie of 6 *gr.* in the *meridian*, and setting one foote in *A*, hauing latitude of 50 *gr.* turne the other to the parallell of 55 *gr.* and it shall there cut off the required difference of longitude *B C* 5 *gr.* $\frac{1}{2}$.

In the same maner, the *Sector* being opened to a right angle, in the lines of *lines*: if we take the difference of latitude out of the line of *meridians* in his proper place from 50 *gr.* vnto 55 *gr.* and place it on one of the lines from the center; then take 6 *gr.* the distance vpon the Rumb out of the same line of *meridians*, according to the latitudes of the places, and set the one foote in the terme of the former difference, turning the other foote to the other perpendicular line, we shall finde that it will crosse it about 5 *gr.* $\frac{1}{2}$ from the center: which is the difference of longitude required.

But if this difference of longitude were to be found by the common sea-chart, it would seeme to be only 3 *gr.* 20 *m.* which is more then 2 *gr.* 10 *m.* lesse then the truth.

12 *By one latitude, distance and difference of longitudes, to finde the difference of latitudes.*

Let the *Sector* be opened in the line of *lines* to a right angle and let the difference of longitude be reckoned in one of those lines from the center; then take the proper distance with a paire of compasses, and setting the one foote in the terme of the former difference, turne the other foote to the other line of the *Sector*, and it shal thence cut off a line, equal to the proper difference of latitude required.

So if the places giuen were *A* and *C*, *A* in the latitude of 50 *gr.* *C* in a greater latitude but vnknowne, the difference of longitude betweene them 5 *gr.* $\frac{1}{12}$, and the distance vpon the Rumb 6 *gr.* or 120 leagues, we shall find the difference of latitude to be 5 *gr.*

For in the chart, let occult meridians be drawne through *A* and *C*, and a parallell of latitude through *A*; then open the compasses according to the estimated latitudes of the places to *E F* the quantitie of 6 *gr.* in the meridian, and setting the one foote in *A*, turne the other to the meridian drawne through *C*, and it shall there cut off the line *D C*, which is the difference of latitude required.

In the same maner, the *Sector* being opened to a right angle, in the lines of *lines*, if in the one line we reckon the difference of longitude from the center to 5 *gr.* $\frac{1}{12}$, then taking 6 *gr.* or the distance out of the line of *Meridians*, according to the latitude of the places, we set the one foote in the terme of the giuen difference, and turne the other foote to the other perpendicular line, we shall finde that it cuts a line from it, which taken and measured in the line of *meridians*, from 50 *gr.* on forward, doth shew the difference of latitude to be as before 5 *gr.*

But if this difference of latitude were to be found by the common sea-chart, it would seeme to be only 2 *gr.* 25 *m.* which is 2 *gr.* 35 *m.* lesse then the truth. Such is the difference betweene both these charts.

THE

THE THIRD BOOKE

Containing the vſe of the particular *Lines.*

THE lines of *lines*, of *ſuperficies*, of *ſolids*, of *ſines*, with the laterall lines of *tangents* and *meridians*, whereof I haue hitherunto ſpoken, are thoſe which I principally intended: that little roome on the *Sector* which remaineth, may be filled vp with ſuch particular lines as each one ſhall think conuenient for his purpoſe. I haue made choiſe of ſuch as I thought might be beſt prickt on without hindring the ſight of the former, viz. lines of *Quadrature*, of *Segments*, of *Inſcribed bodies*, of *Equated bodies*, and of *Mettals*.

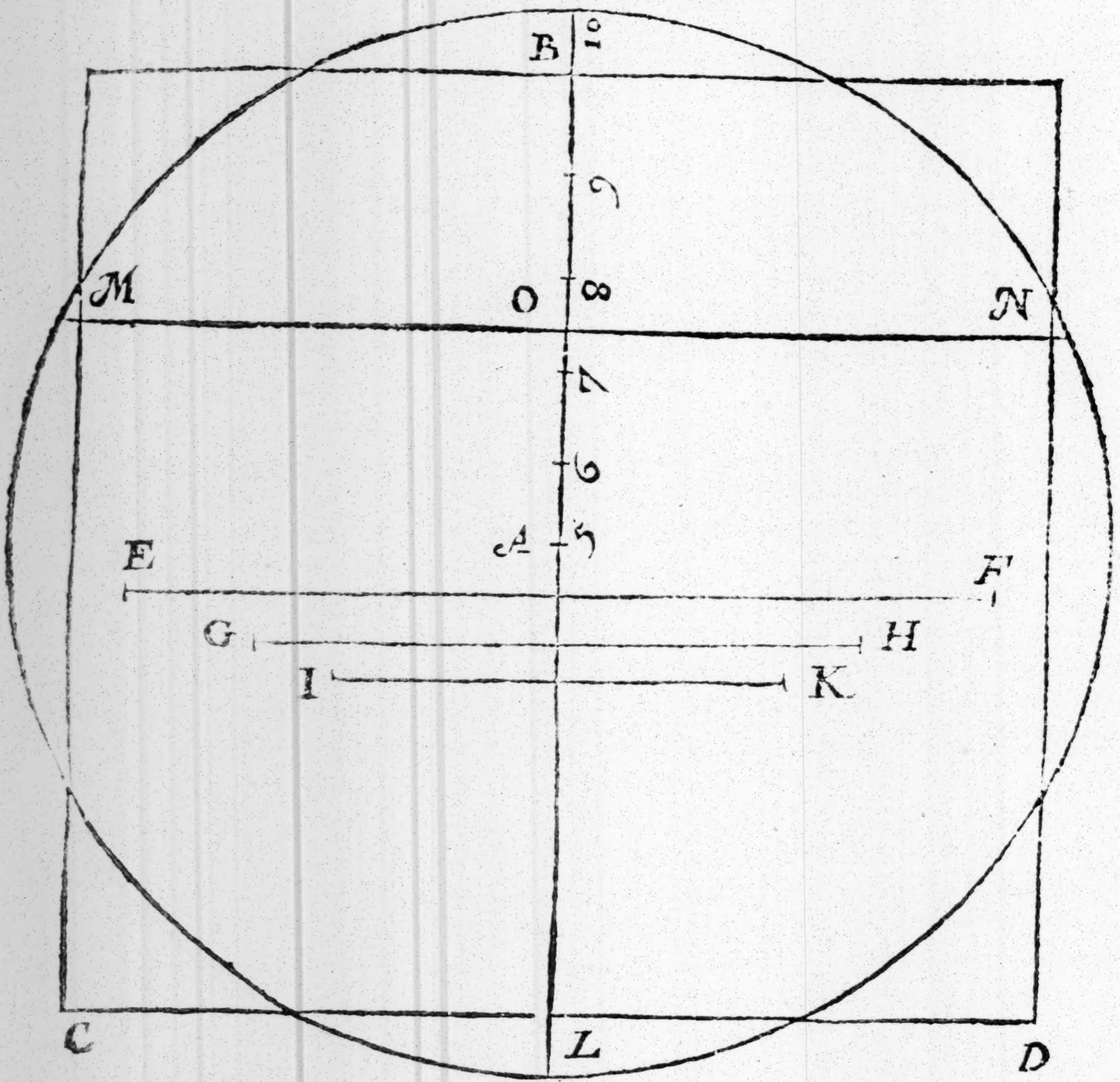
CHAP. I.

Of the lines of Quadrature.

THe lines of *quadrature* may be knowne by the letter *Q*, and by their place betweene the lines of *ſines*. *Q* ſignifieth the ſide of a *ſquare*; 5 the ſide of a *pentagon* with fiue equall ſides, 6 of an *hexagon* with ſix equall ſides, and ſo 7, 8, 9, and 10. *S* ſtands for the Semidiameter of a circle, and 90 for a line equall to 90 *gr.* in the circumference. The vſe of them may be

1 *To make a ſquare equall to a circle giuen.*
2 *To make a circle equall to a ſquare giuen.*

If the circle be firſt giuen, take his ſemidiameter, and to it open the *Sector* in the points at *S*: ſo the parallell taken from betweene the points at *Q*, ſhall be the ſide of the ſquare required.



If the ſquare be giuen take his ſide,and to it open the *Se-ctor*, in the points at *Q*: ſo the parallell taken from betweene the points at *S*, ſhall be the Semidiameter of the circle requi-red.

Let the Semidiameter of the circle giuen be **A B**, the ſide of the ſquare equall vnto it ſhall be found to be **C D.**

3 *To reduce a circle giuen, or a ſquare into an equall pen-tagon, or other like ſided and like angled figure.*

Take the ſide of the figure giuen, and fit it ouer in his due points: ſo the parallels taken from betweene the points of the

the other figures, ſhall be the ſides of thoſe figures: which being made vp with equall angles, ſhall be all equall one to the other.

Let the Semidiameter of the circle giuen be *AB*, the ſide of an *hexagon* equal to this circle, ſhall by theſe meanes be found to be *GH*; and the ſides of an octagon to be *IK*. Other planes not here ſet downe, may firſt be reduced into a ſquare, by the ſixt *Prop. Superf.* and then into a circle, or other of theſe equall figures, as before.

4 *To find a right line, equall to the circumference of a circle, or other part thereof.*

Take the Semidiameter of the circle giuen, and to it open the *Sector* in the points at *S*; ſo the parallell taken from betweene the points at 90 in this line, ſhall be the fourth part of the circumference: which being knowne, the other parts may be found out by the ſecond and third *Prop.* of *lines*.

Thus if the Semidiameter of the circle giuen be *A B*, the right line *E F* ſhall be found to be the fourth part of the circumference. Therefore the double of *E F* ſhall be equall to the circumference of 180 *gr*; and the halfe of *E F* ſhal be the circumference of 45 *gr.* and ſo in the reſt.

CHAP. II.

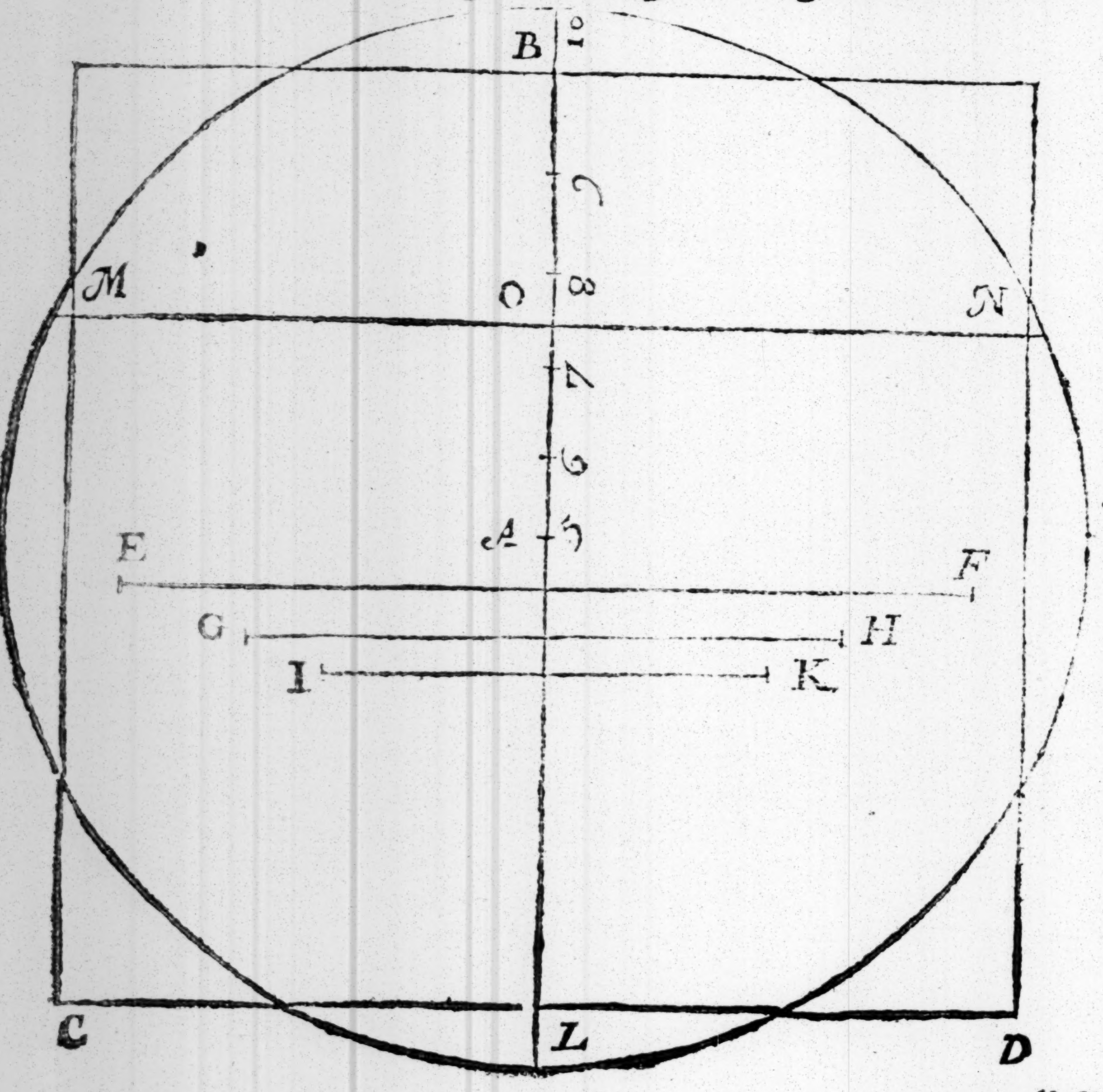
Of the lines of Segments.

THe lines of *ſegments* which are here placed betweene the lines of *ſines* and *ſuperficies*, and are numbred by 5, 6, 7, 8, 9, 10, do repreſent the diameter of a circle, ſo diuided into a hundred parts, as that a right line drawne through theſe parts, perpendicular to the diameter, ſhall cut the circle into two ſegments, of which the greater ſegment ſhall haue that proportion to the whole circle, as the parts cut haue to 100. The vſe of them may be

1 *To diuide a circle giuen into two ſegments, according to a proportion giuen.*
2 *To finde a proportion betweene a circle and his ſegments giuen.*

Let the *Sector* be opened in the points of an 100, to the diameter of the circle giuen: ſo a parallell taken from the points proportionall to the greater ſegment required, ſhall giue the depth of that greater ſegment.

Or if the ſegments be giuen, let the *Sector* be opened as before; then take the depth of the greater ſegment, and carry it



parallell

parallell to the diameter: so the number of points wherein they stay, shall shew the proportion to 100.

As if the diameter of the circle giuen were *B L*, the depth of the greater segment *L O* being 75, doth shew the proportion of the segment *O M L N* to the circle to be as 75 to 100. viz. three parts of foure.

Hence I might shew, if there were any vse of it,

To find the side of a square, equall to any knowne segment of a circle.

The side of a square equall to the whole circle, may be found by the former *Cap.* and then hauing the proportion of the segment to the circle, we may diminish the square in such proportion, by that which hath been shewed *Lib.* 1. *Cap.* 3. *Prop.* 3.

CHAP. III.

Of the lines of Inscribed bodies.

THe lines of *inscribed bodies* are here placed betweene the lines of *lines*, and may be knowne by the letters, *D, S, I, C, O, T*; of which *D* signifieth the side of a *dodecahedron*, *I* of an *Icosahedron*, *C* of a *cube*, *O* of an *octahedron*, and *T* of a *tetrahedron*, all inscribed into the same sphere, whose semidiameter is here signified by the letter *S*.

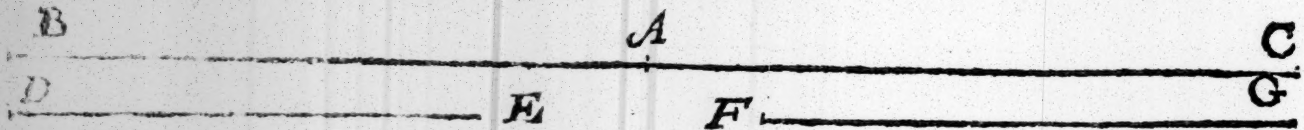
The vse of these lines may be,

1 *The semidiameter of a sphere being giuen, to find the sides of the fiue regular bodies, which may be inscribed in the said sphere.*

2 *The side of any of the fiue regular bodies being giuen, to find the semidiameter of a sphere, that will circumscribe the said bodie.*

If the sphere be first giuen, take his semidiameter, and to it

open the *Sector* in the points at *S*: if any of the other bodies be firſt giuen, take the ſide of it, and fit it ouer in his due points: ſo the parallell taken from betweene the points of the other bodies, ſhall be the ſides of thoſe bodies, and may be inſcribed into the ſame ſphere.



So if the ſemidiameter of the ſphere be *A C*, the ſide of the *dodecahedron* inſcribed ſhall be *D E*.

CHAP. IIII.

Of the lines of Equated bodies.

THe lines of *equated bodies* are here placed betweene the lines of *lines* and *ſolids*, noted with theſe letters, *D*, *I*, *C*, *S*, *O*, *T*, of which *D* ſtands for the ſide of a *dodecahedron*, *I* for the ſide of an *Icoſahedron*, *C* for the ſide of a *cube*, *S* for the diameter of a *ſphere*, *O* for the ſide of an *octahedron*, and *T* for the ſide of a *tetrahedron*, all equall one to the other. The vſe of theſe lines may be

1 *The diameter of a ſphere being giuen, to find the ſides of the fiue regular bodies equall to that ſphere.*

2 *The ſide of any of the fiue regular bodies being giuen, to find the diameter of a ſphere, and the ſides of the other bodies, equall to the firſt body giuen.*

If the ſphere be firſt giuen, take his diameter, and to it open the *Sector* in the points at *S*: if any of the other bodies be firſt giuen, take the ſide of it, and fit it ouer in his due points: ſo the parallels taken from betweene the points of the other bodies, ſhall be the ſides of thoſe bodies equall to the firſt body giuen.

Thus in the laſt diagram, if the diameter of a ſphere giuen be *B C*, the ſide of the *dodecahedron* equall to this ſphere, would be found to be *F G*.

CHAP. V.

Of the Lines of Mettalls.

THe lines of *Mettalls* are here ioyned with those before of *equated bodies,* and are noted with these characters ☉. ☿. ♄. ☽. ♀. ♂. ♃. of which ☉ stands for gold, ☿ for quicksiluer, ♄ for leade, ☽ for siluer, ♀ for copper, ♂ for iron, and ♃ for tin. The vse of them is to giue a proportion betweene these seuerall mettalls, in their magnitude and weight, according to the experiments of *Marinus Ghetaldus,* in his booke called *Promotus Archimedes.*

1 *In like bodies of seuerall mettalls and equall weight, hauing the magnitude of the one, to finde the magnitude of the rest.*

Take the magnitude giuen out of the lines of *Solids,* and to it open the *Sector* in the points belonging to the mettall giuen: so the parallells taken from betweene the points of the other mettalls, and measured in the lines of *Solids,* shall giue the magnitude of their bodies.

Thus hauing cubes or spheres of equall weight, but seuerall mettalls, we shall finde that if those of tin containe 10000 *D.* the others of iron wil contain 9250, those of copper 8222, those of siluer 7161, those of lead 6435, those full of quicksiluer 5453, and those of gold 3895.

2 *In like bodies of seuerall mettalls and equall magnitude, hauing the weight of one to finde the weight of the rest.*

This proposition is the conuerse of the former, the proportion not direct, but reciprocall, wherefore hauing two like bodies, take the giuen weight of the one out of the lines of *Solids,* and to it open the *Sector* in the points belonging to

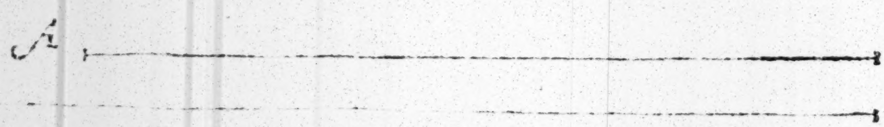
the mettall of the other body: so the parallell taken from the points belonging to the body giuen, and measured in the lines of *Solids*, shall giue the weight of the body required.

As if a cube of gold weighed 38 ℔. and it were required to know the weight of a cube of lead hauing equal magnitude. First I take 38 ℔. for the weight of the golden cube, out of the lines of *Solids*, & put it ouer in the points of ♄ belonging to lead: so the parallell taken from betweene the points of ☉ standing for gold, and measured in the lines of *Solids*, doth giue the weight of the leaden cube required to be 23 ℔.

Thus if a sphere of gold shall weigh 10000, we shall finde that a sphere of the same diameter full of quicksiluer shall weigh 7143, a sphere of lead 6053, a sphere of siluer 5438, a sphere of copper 4737, a sphere of iron 4210, and a sphere of tin 3895.

3 *A bodie being giuen of one mettall, to make another like vnto it, of another mettall, and equall weight.*

Take out one of the sides of the bodie giuen, and put it ouer in the points belonging to his mettall: so the parallell taken from betweene the points belonging to the other mettall, shall giue the like side, for the bodie required. If it be an irregular bodie, let the other like sides be found out in the same manner.



Let the bodie giuen be a sphere of lead containing in magnitude 16 D, whose diameter is *A*, to which I am to make a sphere of iron, of equall waight: If I take out the diameter *A*, and put it ouer in the points of ♄ belonging to lead, the parallell taken from betweene the points of ♂ standing for iron, shall be *B*, the diameter of the iron sphere required. And this compared with the other diameter, in the lines of

Solids,

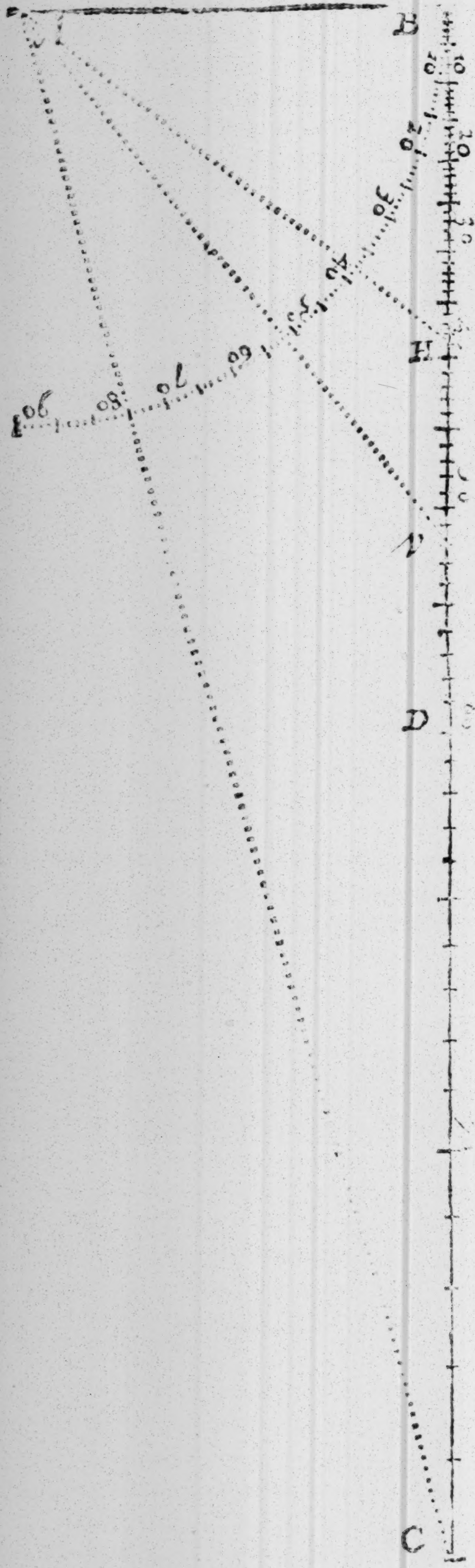
ſolids will be found to be 23 *d.* in magnitude.

4 *A body being giuen of one mettall, to make another like vnto it of another mettall, according to a weight giuen.*

First find the ſides of a like bodie of equall weight, then may we either augment or diminiſh them according to the proportion giuen by that which we ſhewed before in the ſecond and third *Prop.* of *Solids.*

As if the bodie giuen were a ſphere of lead, whoſe diameter is *A*, and it were required to find the diameter of a ſphere of iron, which ſhall weigh three times as much as the ſphere of lead: I take *A*, and put it ouer in the points of ♄, his parallell taken from betweene the points of ♂, ſhall giue me *B* for the diameter of an equall ſphere of iron: if this be augmented in ſuch proportion as 1 vnto 3, it giueth *C* for the diameter required.

CHAP.



CHAP. VI.

Of the lines on the edges of the Sector.

HAuing shewed some vse of the lines on the flat sides of the *Sector*, there remaine onely those on the edges. And here one halfe of the outward edge is diuided into inches, and numbred according to their distance from the ends of the *Sector*. As in the Sector of fourteene inches long, where we find 1 and 13, it sheweth that diuision to be 1 inch from the nearer end, and 13 inches from the farther end of the *Sector*.

The other halfe containeth a line of lesser *tangents*, to which the gnomon is Radius. They are here continued to 75 *gr.* And if there be need to produce them farther, take 45 out of the number of degrees required, and double the remainder: so the *tangent* and *secant* of this double remainder being added, shall make vp the *tangent* of the degrees required.

As if *A B* being the Radius, and *B C* the tangent line, it were required to find the tangent of 75 *gr.* If we take 45 *gr.* out of 75 *gr.* the remainer is 30 *gr.* and the double 60 *gr* whose tangent is B D, and the secant is A D: if then we adde A D to B D, it maketh *B C* the tangent of 75 *gr.* which was required. In like sort the secant of 61 *gr.* added to the tangent of 61 *gr.* giueth the tangent of 75 *gr.* 30 *m.* and the secant of 62 *gr.* added to the tangent of 62 *gr.* giueth the tangent of 76 *gr.* and

and ſo in the reſt. The vſe of this line may be

To obſerue the altitude of the Sunne.

Hold the *Sector* ſo as the tangent *BC* may be verticall,and the gnomon *B A* parallell to the horizon; then turne the gnomon toward the Sunne,ſo that it may caſt a ſhadow vpon the tangent,and the end of the ſhadow ſhal ſhew the altitude of the Sunne.So if the end of the gnomon at *A*, do giue a ſhadow vnto *H*, it ſheweth that the altitude is 38 *gr.* $\frac{1}{2}$,if vnto D,then 60 *gr.* and ſo in the reſt.

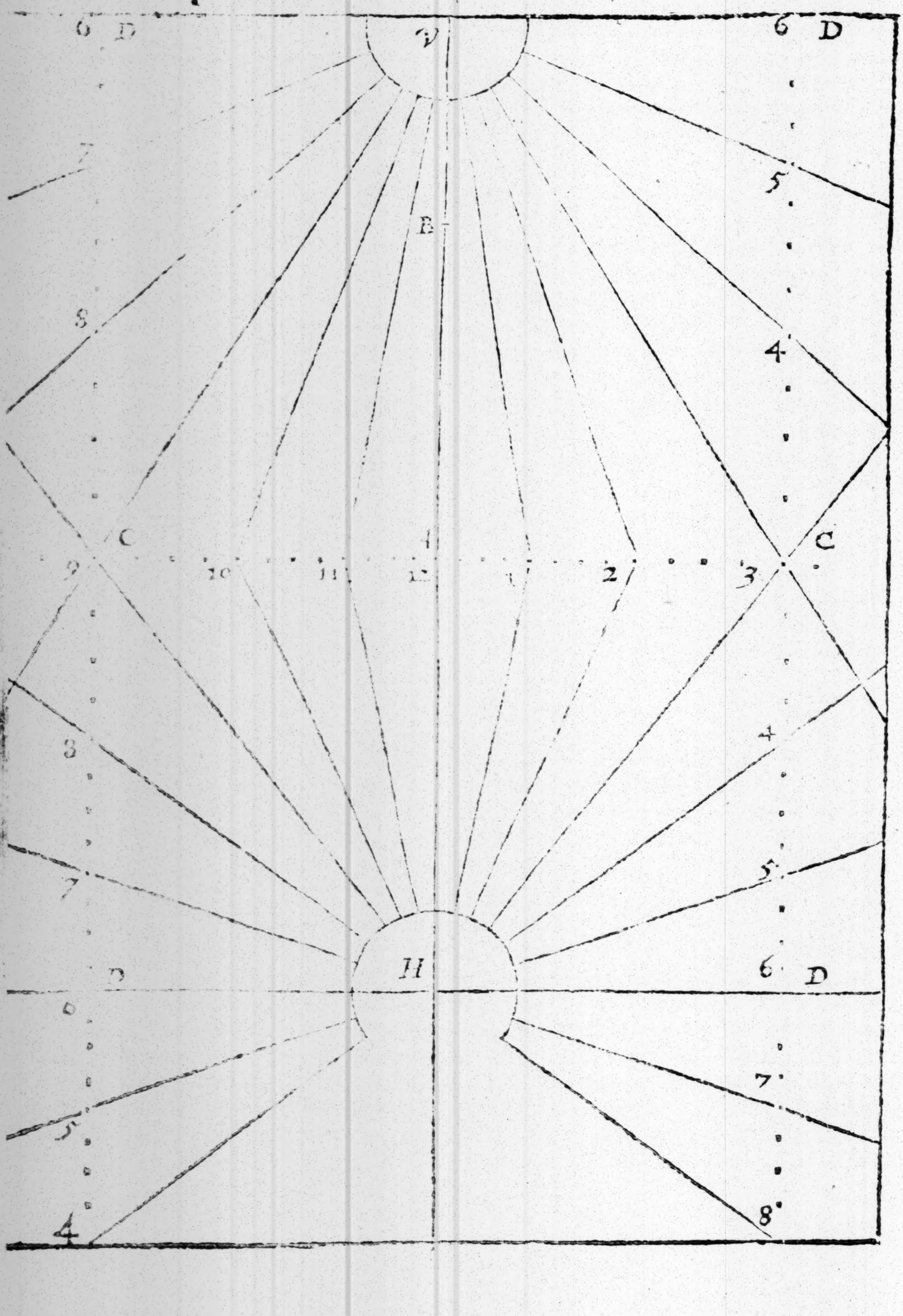
There is another vſe of this *tangent* line, for the drawing of the houre lines vpon any ordinary plane, whereof I will ſet downe theſe propoſitions.

1 *To draw the houre lines vpon an horizontall plane.*
2 *To draw the houre lines vpon a direct verticall plane.*

First draw a right line *AC* for the horizon and the equator, and croſſe it at the point *A* about the middle of the line with *AB* another right line,which may ſerue for the meridian and the houre of 12; then take out 15 *gr.* out of the tangents,and pricke them downe in the equator on both ſides from 12: ſo the one point ſhall ſerue for the houre of 11, and the other for the houre of 1. Againe,take out the tangent of 30 *gr.* and pricke it downe in the equator on both ſides from 12: ſo the one of theſe points ſhall ſerue for the houre of 10, and the other for the houre of 2. In like maner may you prick downe the tangent of 45 *gr.* for the houres of 9 and 3, and the tangent of 60 *gr.* for the houres of 8 and 4, and the tangent of 75 *gr.* for the houres of 7 and 5.

Or if any pleaſe to ſet downe the parts of an houre,he may allow 7 *gr.* 30 *m.* for euery halfe houre,and 3 *gr.* 45 *m.* for euery quarter. This done,you are to conſider the latitude of the place,and the qualitie of the plane: For the *ſecant* of the latitude ſhal be the ſemidiameter in a vertical plane,& the *ſecant* of the complement of the latitude in an horizontall plane.

T For


6 D
V
6 D
7
5
B
8
4
C
C
9
10
11
12
1
2
3
8
4
7
5
D
H
6 D
6
7
5
4
8

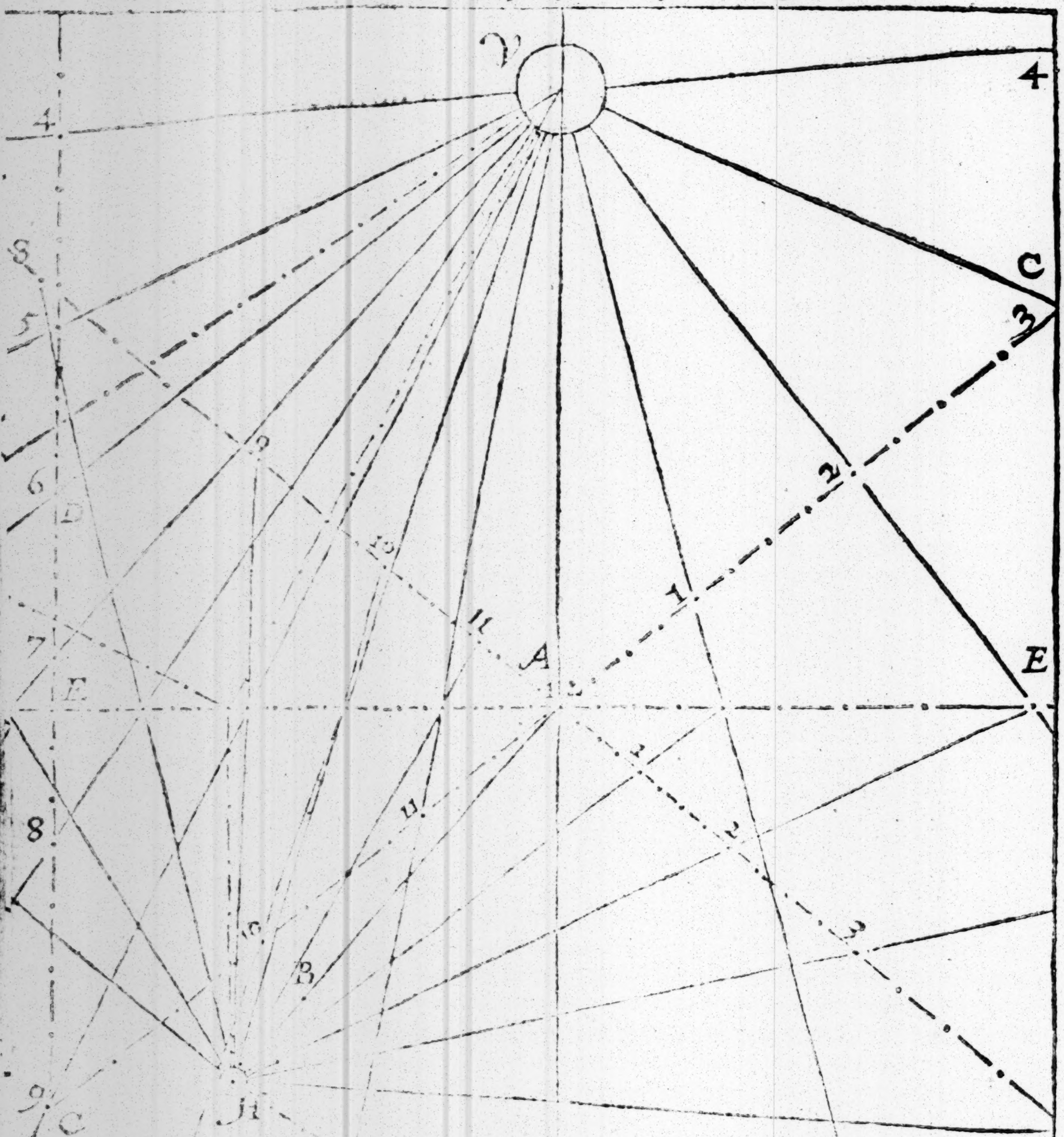
For example, about London the latitude is **51 *gr.* 30 *m.*** and let the plane be verticall. If you take *A V* the secant of **51 *gr.* 30 *m.*** out of the *Sector*, and pricke it downe in the meridian line from *A* vnto *V*, the point *V* shall be the center: and if you draw right lines from *V* vnto **11**, and **10**, and the rest of the houre points, they shall be the houre lines required.

But if the plane be horizontall, then you are to take out *A H* the secant of 38 *gr.* 30 *m.* for the semidiameter, and prick it downe in the meridian line from *A* vnto *H*: so the right lines drawne from the center *H* vnto the houre points, shall be the houre lines required; only the houre of 6 is wanting, and that must alwayes be drawne parallell to the equator, through the center V in a verticall, through the center *H* in an horizontall plane.

3 *To draw the houre lines on a polar plane.*
4 *To draw the houre lines on a meridian plane.*

In a *polar* plane the equator may be also the same with the horizontall line, and the houre points may be pricked on as before, but the houre lines must be drawne parallell to the meridian.

In a meridian plane, the equator will cut the horizontall line with an angle equall to the complement of the latitude of the place; then may you make choise of the point *A*, and there crosse the equator with a right line, which may serue for the houre of 6: so the tangent of 15 *gr.* being pricked downe in the equator on both sides from 6, shal serue for the houres of fiue 5 and 7; and the tangent of 30 *gr.* for the houres of 8 and 4; and the tangent of 45 *gr.* for the houres of 3 and 9; and the tangent of 60 *gr.* for the houres of 2 and 10; and the tangent of 75 *gr.* for the houres of 1 and 11. And if you draw right lines through these houre points, crossing the equator at right angles, they shall be the houre lines required.



5 *To draw the houre lines in a verticall declining place.*

First, draw *A V* the meridian, and *A E* the horizontal line, crossing one the other at right angles in the point *A*.

2 Then

2 Then take out *AV*, the secant of the latitude of the place, which you may suppose to be 51 *gr.* 30 *m.* and prick it downe in the meridian line from *A* vnto *V*.

3 Because it is a declining plane, and you may suppose it to decline 40 *gr.* Eastward, you are to make an angle of the declination vpon the center *A*, below the horizontall line, and to the left hand of the meridian line, because the declination is Eastward, for otherwise it should haue bin to the right hand, if the declination had bin Westward.

4 Take *A H*, the secant of the complement of the latitude out of the *Sector*, & pricke it downe in the line of declination from *A* vnto *H*, as you did before for the semidiameter in the horizontall plane.

5 Draw a line at full length through the point *A*, which must be perpendicular vnto *A H*, and cut the horizontall line according to the angles of declination, and it will be as the equator in the horizontall plane.

6 Take the houre points out of the *Tangent* line in the *Sector*, and pricke them downe in this equator on both sides from the houre of 12 at *A*.

7 Lay your ruler, & draw right lines through the center *H*, & each of these houre points: so haue you all the houre lines of an horizontall plane, onely the houre of 6 is wanting, and that may be drawne through *H* perpendicular to *H A*.

Lastly you are to obserue and make the intersections, which these houre lines do make with *A E* the horizontall line of the plane: and then if you draw right lines through the center *V*, and each of these intersections, they shal be the houre lines required.

6 *To pricke downe the houre points another way.*

Hauing drawne a right line for the equator as before, and made choice of the point *A*, for the houre of 12: you may at pleasure cut of two equal lines *A* 10, and *A* 2. Then vpon the distance betweene 10 and 2, make an equilaterall triangle, and you shall haue *E* for the center of your equator, and the

line *A B* shall giue the distance from *A* to 9, and from A to 3. That done take out the distance betweene 9 and 3, and this shall giue the distance from *B* vnto 8, and from 8 vnto 7, and from 8 vnto 1: and againe from B vnto 4, and from 4 vnto 5, and from 4 vnto 11. So haue you the houre points, and if you take out the distance B 1, B 3, B 5, &c. You may finde the points not onely for the halfe houres, but also for the quarters.

But if it so fall out, that some of these houre points fall out of your plane, you may helpe your selfe by the larger *tangent*, both in the verticall, and horizontall planes.

For if at the houre points of 3 and 9, you draw occult lines parallell to the meridian; the distances D C, betweene the houre line of 6, and the houre points of 3 and 9, will be equal to the semidiameter A V in a verticall, and AH in a horizontall plane, and if they be diuided in such sort as the line A C is diuided, you shall haue the points of 4, and 5, and 7, and 8, with their halfes and quarters.

As in the horizontall plane, take out the semidiameter A H, and make it a parallell Radius by fitting it ouer in the *sines* of 90 and 90: Then take 15 *gr.* out of the larger *tangent*, and lay them on the lines of *sines*, where they will reach from the center vnto the sines of 15 *gr.* 32 *m.* therefore take out the parallell sine of 15 *gr.* 32 *m.* and it shall giue the distance from 6 vnto 5, and from 6 vnto 7, in your horizontall plane. That done take out 30 *gr.* out of the larger *tangent*, and lay them on the *sines*, from the center vnto the sines of 35 *gr.* 16 *m.* and the parallell sine of 35 *g.* 16 *m.* shall giue you the distance from 6 vnto 4, and from 6 vnto 8, in your horizontall plane. The like may be done for the halfe houres and quarters.

So also in the verticall declining plane. If you first take out the *secant* of the declination of the plane, and prick it downe in the horizontall line from A vnto E, and through E draw right lines parallell to the meridian, which will cut the former houre lines of 3 and 9, or one of them in the point C: then take out the semidiameter A V, and prick it downe in

those

those parallells from C vnto D, and draw right lines from A vnto C, and from V vnto D; the line V D shall be the houre of 6, and if you diuide these lines A C and D C, in such sort as you diuided the like line D C in the horizontall plane, you shall haue all the houre points required.

Or you may find the point D, in the houre of 6, without knowledge either of *H* or *C*. For hauing prickt downe *A V* in the meridian line, and *A E* in the horizontall line, and drawne parallels to the meridian through the points at *E*, you may take the *tangent* of the latitude out of the *Sector*, and fit it ouer in the sines of 90 and 90: so the parallell sine of the declination measured in the same *tangent* line, shall there shew the complement of the angle DVA, which the houre line of 6 maketh with the meridian; then hauing the point D, take out the semidiameter VA, and pricke it downe in those parallels from D vnto C: so shall you haue the lines D C and A C to be diuided as before.

The like might be vsed for the houre lines vpon all other planes. But I must not write all that may be done by the *Sector*. It may suffice that I haue wrote something of the vse of each line, and thereby giuen the ingenuous Reader occasion to thinke of more.

The conclusion to the Reader.

It is well knowne to many of you, that this Sector was thus contriued, the most part of this booke written in Latin, many copies transcribed and dispersed more then sixteene yeares since. I am at the last contented to giue way that it come forth in English. Not that I thinke it worthy either of my labour or the publique view, but partly to satisfy their importunity, who not vnderstanding the Latin, yet were at the charge to buy the instrument, and partly for my owne ease. For as it is painefull for others to transcribe my copie, so it is troublesome for me to giue satisfaction herein to all that desire it. If I finde this to giue you content, it shall incourage me to do the like for my Crosse-staffe, *and some other Instruments. In the meane time beare with the Printers faults, and so I rest.*

Gresham Coll. 1. Maij. 1623. E. G.

FINIS.

THE FIRST BOOKE OF THE *CROSSE-STAFFE.*

CHAP. I.

Of the description of the Staffe.

THe *Crosse-Staffe* is an instrument wel knowne to our Sea-men, and much vsed by the ancient Astronomers and others, seruing Astronomically for obseruation of altitude and angles of distance in the heauens, Geometrically for perpendicular heights and distances on land and sea.

The description and seuerall vses of it are extant in print, by *Gemma Frisius* in Latin, in English by *Dr. Hood.* I differ something from them both, in the proiection of this *Staffe*, but so, as their rules may be applied vnto it, and all their propositions be wrought by it: and therefore referring the Reader to their bookes, I shal be briefe in the explanation of that which may be applied from theirs vnto mine, and so come to the vse of those lines which are of my addition, not extant heretofore.

The necessary parts of this Instrument are fiue: the *Staffe*, the *Crosse*, and the three *sights*. The Staffe which I made for my owne vse, is a full yard in length, that so it may serue for measure.

The

The Crosse belonging to it is 26 inches ½ betweene the two outward sights. If any would haue it in a greater forme, the proportion betweene the Staffe and the Crosse, may be such as 360 vnto 262.

The lines inscribed on the Staffe are of foure sorts. One of them serues for measure and protraction: one for obseruation of angles: one for the Sea-chart; and the foure other for working of proportions in seuerall kinds.

The line of measure is an *inch line*, and may be knowne by his equall parts. The whole yard being diuided equally into 36 inches, and each inch subdiuided, first into ten parts, and then each tenth part into halfes.

The line for obseruation of angles may be knowne by the double numbers set on both sides of the line, beginning at the one side at 20, and ending at 90: on the other side at 40, and ending at 180: and this being diuided according to the degrees of a quadrant, I call it the ***tangent line on the Staffe***.

The next line is the meridian of a Sea-chart, according to *Mercators* proiection from the Equinoctiall to 58 *gr.* of latitude, and may be knowne by the letter *M*, and the numbers 1.2.3.4. vnto 58.

The lines for working of proportions, may be knowne by their vnequall diuisions, and the numbers at the end of each line.

1 The line of ***numbers*** noted with the letter N, diuided vnequally into 1000 parts, and numbred with 1.2.3.4. vnto 10.

2 The line of ***artificiall tangents*** is noted with the letter *T*, diuided vnequally into 45 degrees, and numbred both ways, for the Tangent and the complement.

3 The line of ***artificiall sines***, noted with the letter *S*, diuided vnequally into 90 degrees, and numbred with 1.2.3.4. vnto 90.

4 The line of ***versed sines*** for more easie finding the houre and azimuth, noted with V, diuided vnequally into about 164 *gr.* 50 *m.* numbred backward with 10.20.30. vnto 164.

Thus there are seuen lines inscribed on the Staffe: there are fiue lines more inscribed on the Crosse.

1 A Tangent line of 36 *gr.* 3 *m.* numbred by 5.10.15. vnto 35: the midst whereof is at 20 *gr*; and therefore I call it the *tangent of* 20; and this hath respect vnto 20 *gr.* in the Tangent on the Staffe.

2 A Tangent line of 49 *gr.* 6 *m.* numbred by 5.10.15. vnto 45; the midst whereof is at 30 *gr.* and hath respect vnto 30 *gr.* in the Tangent on the Staffe, whereupon I call it the *tangent of* 30.

3 A line of *inches* numbred with 1.2.3. vnto 26; each inch equally subdiuided into ten parts, answerable to the inch line vpon the Staffe.

4 A line of seuerall *chords*, one answerable to a circle of twelue inches semidiameter, numbred with 10.20.30. vnto 90: another to a semidiameter of a circle of six inches; and the third to a semidiameter of a circle of three inches; both numbred with 10.20.30. vnto 90.

5 A continuation of the *meridian* line from 57 *gr.* of latitude vnto 76 *gr*; and from 76 *gr.* to 84 *gr.*

For the inscription of these lines. The first for measure is equally diuided into inches and tenth parts of inches.

The tangent on the Staffe for obseruation of angles, with the tangent of 20 and the tangent of 30 on the Crosse, may all three be inscribed out of the ordinary *table of tangents*. The Staffe being 36 inches in length; the Radius for the tangent on the Staffe will be 13 inches and 103 parts of 1000: so the whole line will be a tangent of 70 *gr.* and must be numbred by their complements, & the double of their complements, the tangent of 10 *gr.* being numbred with 80 and 160.

The Radius for the tangent of 20 on the Crosse, will be 8 inches, and the whole line betweene the sights a tangent of 36 *gr.* 3 *m.* according as it is numbred. The Radius for the tangent of 30 *gr.* on the Crosse, will be 22 inches and 695 parts of 1000: so the whole line betweene the sights wil containe a tangent of 49 *gr.* 6 *m.* in such sort as they are numbred.

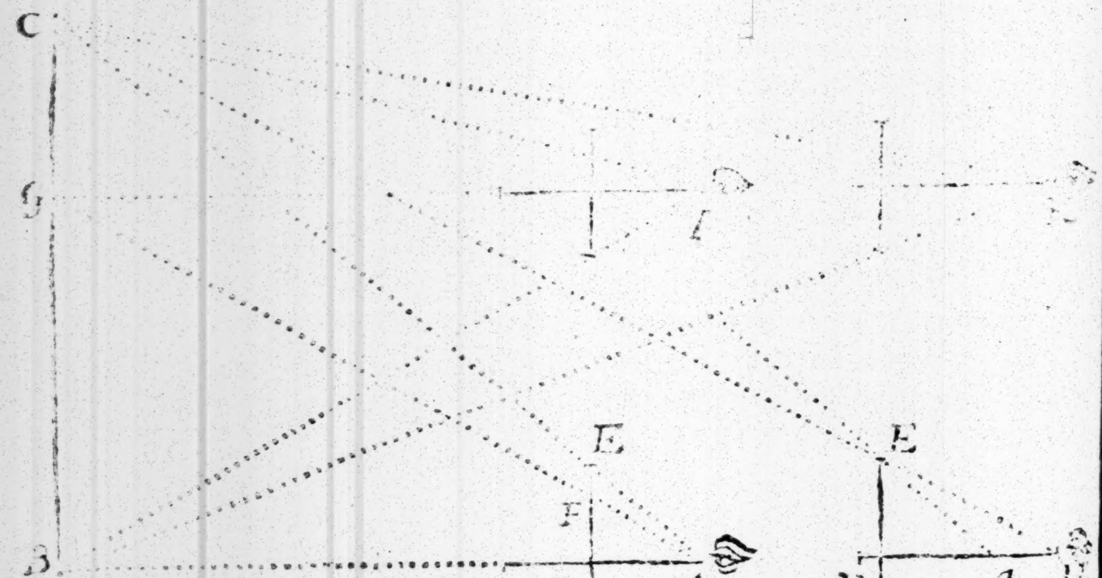
The meridian line may be inscribed out of the Table which I set downe for this purpose in the vse of the Sector.

The line of numbers may be inscribed out of the first Chi-[illegible]d of Mr. *Briggs* Logarithmes: & the rest of the lines of pro-portion out of my *Canon of artificiall sines and tangents*; and in recompence thereof this booke will serue as a comment to explane the vse of my *Canon*.

CHAP. II.

The vse of the lines of inches *for perpendicular heights and distances.*

IN taking of heights and distances, the Staffe may be held in such sort, that it may be euen with the distance, and the Crosse parallell with the height: and then if the eye at the beginning of the Staffe shall see his marks by the inward sides of the two first sights, there will be such proportion be-tweene the distance and the height, as is betweene the parts intercepted on the Staffe and the Crosse. Which may be far-ther explaned in these propositions.



1 *To find an height at one station, by knowing the distance.*

Set the middle sight vnto the distance vpon the Staffe

th

the height will be found vpon the Crosse. For

As the segment of the Saffe
vnto the segment on the Crosse:
So is the distance giuen,
vnto the height.

As if the distance *A B* being knowne to be 256 feete, it were required to find the height *B C*: first I place the middle sight at 25 *inches* and 6 *parts* of 10; then holding the Staffe leuell with the distance, I raise the Crosse, parallell vnto the height, in such sort, as that my eye may see from *A* the beginning of the inches on the Staffe by the sight *E*, at the beginning of the inches on the Crosse vnto the mark *C*: which being done, if I find 19 inches and 2 parts of 10 intercepted on the Crosse betweene the sights at *E* and *D*, I would say the height *B C* were 192 feete.

Or if the obseruation were to be made before the distance were measured, I would set the middle sight either vnto 10 inches, or 12, or 16, or 20, or 24, or some such other number as might best be diuided into seuerall parts, and then worke by proportion. As if in the former example the middle sight were at 24 on the Staffe, and 18 on the Crosse, it should seem that the height is $\frac{3}{4}$ of the distance; and therefore the distance being 256, the height should be 192.

2 *To finde an height, by knowing some part of the same height.*

As if the height from *G* to *C* were knowne to be 48, and it were required to find the whole height *B C*: either put the third sight or some other running sight vpon the Crosse betweene the eye and the marke *G*. For then

As the difference betweene the sights,
vnto the whole segment of the Crosse:
So is the part of the height giuen,
vnto the whole height.

If then the difference betweene the sights *E* and *F*, shall be

be 45, and the segment of the Crosse E D 180, the whole height *B C* will be found to be 192.

3 *To find an height at two stations, by knowing the difference of the same stations.*

As the difference of segments on the Staffe,
vnto the difference of stations:
So is the segment of the Crosse,
vnto the height.

Suppose the first station being at *H*, the segment of the Crosse *E D* were 180, and the segment of the Staffe *H D* 300: then coming 64 feete nearer vnto *B*, in a direct line, vnto a second station at *A*, and making another obseruation; suppose the segment of the Crosse *E D* were 180 as before, and the segment of the Staffe *A D* 240; take 240 out of 300, the difference of segments will be 60 parts. And

As 60 parts vnto 64 the difference of stations:
So D E 180 vnto *B C* 192 the height required.

In these three *Prop.* there is a regard to be had of the height of the eye. For the height measured, is no more then from the leuell of the eye vpward.

4 *To find a distance, by knowing the height.*

As the segment of the Crosse,
vnto the segment of the Staffe:
So is the height giuen,
vnto the distance.

So the segment E D being 18, and D A 24, the height *C B* 192, will shew the distance *A B* to be 256.

5 *To find a distance, by knowing part of the height.*

As the difference betweene the sights,
vnto the segment of the Staffe:

So

So is the part of the height giuen,
vnto the distance.

And thus the difference betweene *E* and *F* being 45, and the segment D A 240; the part of the height *GC* 48, will giue the distance *A* B to be 256.

6 *To finde a distance at two stations, by knowing the difference of the same stations.*

As the difference of segments on the Staffe,
vnto the difference of stations:
So is the whole segment,
vnto the distance.

And thus the segment of the Crosse being 180, the segment of the Staffe at the first station 240, at the second 300, the difference of the segments 60, & the difference of stations 64, the distance A B at the first station will be found to be 256, and the distance H B at the second station 320.

7 *To find a bredth by knowing the distance perpendicular to the bredth.*

This is all one with the first *Prop.* For this bredth is but an height turned sidewayes: and therefore
As the segment of the Staffe,
vnto the segment of the Crosse:
So is the distance
vnto the bredth.

And thus the segment of the Staffe being 24, and the segment of the Crosse 18, the distance A B 256, will giue the bredth B C to be 192.

8 *To find a bredth at two stations in a line perpendicular to the bredth, by knowing the difference of the same stations.*

This is also the same with the third *Prop:* and therefore

As

As the difference of segments on the Staffe,
vnto the difference of stations:
So the segment on the Crosse betweene the two sights,
vnto the bredth required.

And thus the difference betweene the stations at *A* and H being 64, the difference of segments on the Staffe 60, the segment of the Crosse 180, the bredth BC will be found to be 192.

In like maner may we finde the bredth *GC* for hauing found the bredth BC the proportion will hold.

As D E is vnto F E, so B *C* vnto *G C*. Or otherwise,
As H *A* vnto H A, so F E vnto *G C*.

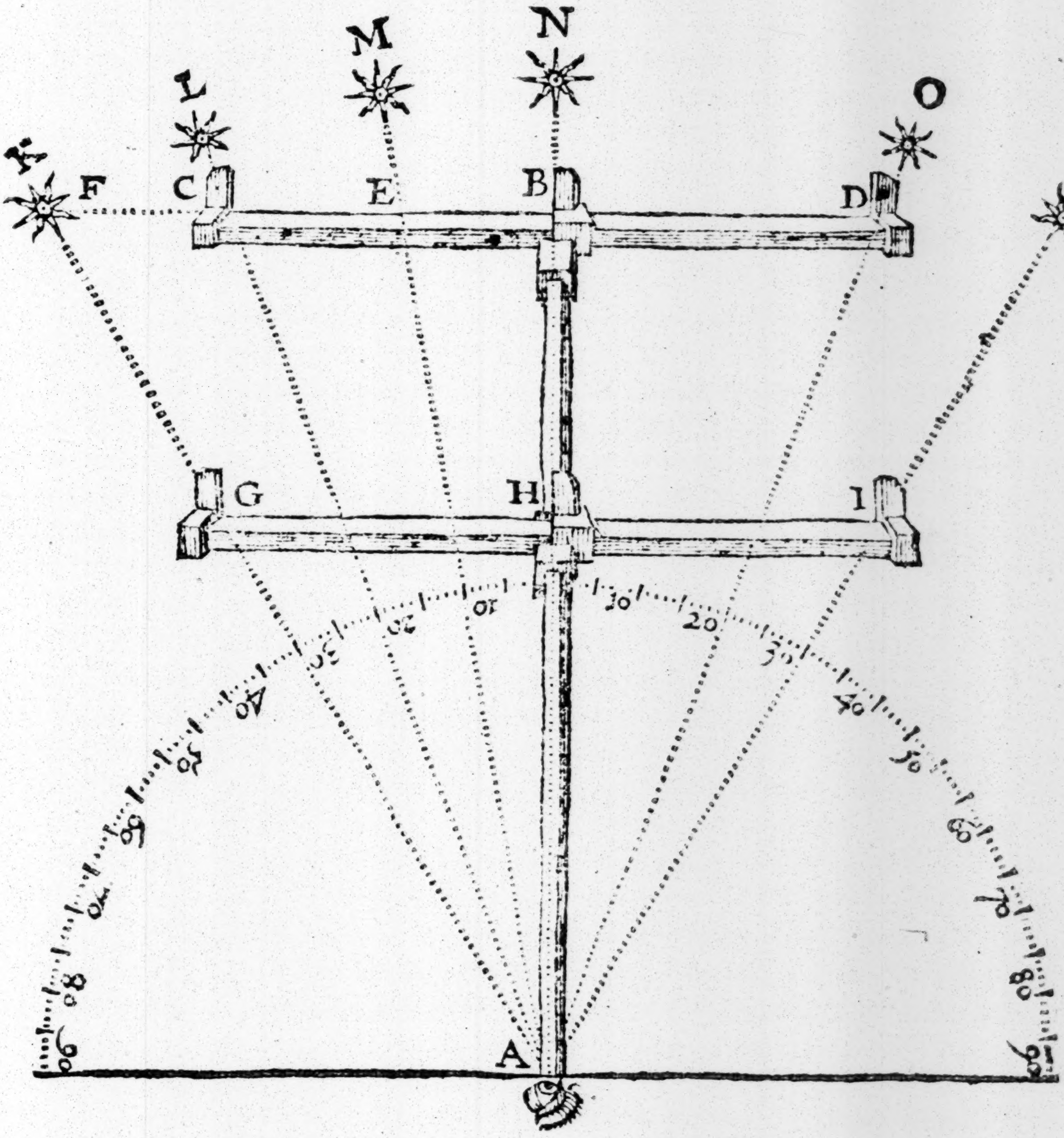
Neither is it materiall whether the two stations be chosen at the one end of the bredth proposed, or without it, or within it, if the line betweene the stations be perpendicular vnto the bredth: as may appeare if in stead of the stations at *A* and H, we make choise of the like stations at *I* and *K*.

There might be other wayes proposed to work these *Prop.* by holding the Crosse euen with the distance, and the *Staffe* parallell with the height: but these would proue more troublesome, and those which are deliuered are sufficient, and the same with those which others haue set downe vnder the name of the *Iacobs staffe*.

CHAP.

CHAP. III.

The vse of the Tangent lines in taking of Angles.



1 *To find an angle by the Tangent on the Staffe.*

LEt the middle sight be alwayes set to the middle of the Crosse, noted with 20 and 30, and then the Crosse

drawne nearer the eye, vntill the marks may be seene close within the sights. For so if the eye at *A* (that end of the Staffe which is noted with 90 and 180) beholding the marks *K* and *N*, betweene the two first sights, *C* and *B*, or the marks *K* and *P* betweene the two outward sights, the Crosse being drawne downe vnto *H*, shall stand at 30 and 60, in the Tangent on the Staffe: it sheweth that the angle *K A N* is 30 *gr.* the angle *K A P* 60 *gr.* the one double to the other; which is the reason of the double numbers on this line of the Staffe: and this way will serue for any angle from 20 *gr.* toward 90 *gr.* or from 40 *gr.* toward 180 *gr.* But if the angle be lesse then 20 *gr.* we must then make vse of the Tangent vpō the Crosse.

2 *To find an angle by the Tangent of 20 vpon the Crosse.*

Set 20 vnto 20, that is, the middle sight to the middest of the Crosse at the end of the Staffe, noted with 20: so the eye at *A* beholding the marks *L* and *N* close betweene the two first sights, *C* and *B*, shall see them in an angle of 20 *gr.*

If the marks shall be nearer together, as are *M* and *N*, then draw in the Crosse from *C* vnto *E*: if they be farther asunder, as are *K* and *N*, then draw out the Crosse from *C* vnto *F*; so the quantitie of the angle shal be still found in the Crosse in the Tangent of 20 *gr.* at the end of the Staffe; and this will serue for any angle from 0 *gr.* toward 35 *gr.*

3 *To find an angle by the Tangent of 30 vpon the Crosse.*

This Tangent of 30 is here put the rather, that the end of the Staffe resting at the eye, the hand may more easily remoue the Crosse: for it supposeth the Radius to be no longer then *A I*, which is from the eye at the end of the Staffe vnto 30 *gr.* about 22 *inches* and 7 *parts.* Wherefore here set the middle sight vnto 30 *gr.* on the Staffe, and then either draw the Crosse in or out, vntill the marks be seene between

the

the two first sights; so the quantitie of the angle will be found in the Tangent of 30, which is here represented by the line *GH*; and this will serue for any angle from 0 gr. toward 48 *gr*.

4 *To obserue the altitude of the Sunne backward.*

Here it is fit to haue an horizontall sight set to the beginning of the Staffe, and then may you turne your backe toward the Sun, and your Crosse toward your eye. If the altitude be vnder 45 *gr.* set the middle sight to 30 on the Staffe, and looke by the middle sight through the horizontall vnto the horizon, mouing the Crosse vpward or downward, vntill the vpper sight doe shadow the vpper halfe of the horizontall sight: so the altitude will be found in the Tangent of 30.

If the altitude shal be more then 45 *gr.* set the middle sight vnto the middest of the Crosse, and look by the inward edge of the lower sight through the horizontall to the horizon, mouing the middle sight in or out, vntill the vpper sight do shadow the vpper halfe of the horizontall sight: so the altitude will be found in the degrees on the Staffe betweene 40 and 180.

5 *To set the Staffe to any angle giuen.*

This is the conuerse of the former *Prop.* For if the middle sight be set to his place and degree, the eye looking close by the sights as before, cannot but see his obiect in the angle giuen.

6 *To obserue the altitude of the Sunne another way.*

Set the middle sight to the middle of the Crosse, and hold the horizontall sight downward, so as the Crosse may be parallell to the horizon, then is the Staffe verticall; and if the outward sight of the Crosse do shadow the horizontall sight,

the complement of the altitude wil be found in the tangent on the Staffe.

7 *To obserue an altitude by thread and plummet.*

Let the middle sight be set to the middest of the Crosse, and to that end of the Staffe which is noted with 90 and 180; then hauing a thread and a plummet at the beginning of the Crosse, and turning the Crosse vpward, and the Staffe toward the Sunne, the thread will fall on the complement of the altitude aboue the horizon. And this may be applied to other purposes.

8 *To apply the lines of inches to the taking of angles.*

If the angles be obserued betweene the two first sights, there wil be such proportion between the parts of the Staffe and the parts of the Crosse, as betweene the Radius and the Tangent of the angle.

As if the parts intercepted on the Staffe were 20 inches, the parts on the Crosse 9 inches. Then by proportion as 20 vnto 9, so 100000 vnto 45000 the tangent of 24 *gr.* 14 *m.*

But if the angle shall be obserued betweene the two outward sights, the parts being 20 and 9 as before, the angle will be 48 *gr.* 28 *m.* double vnto the former.

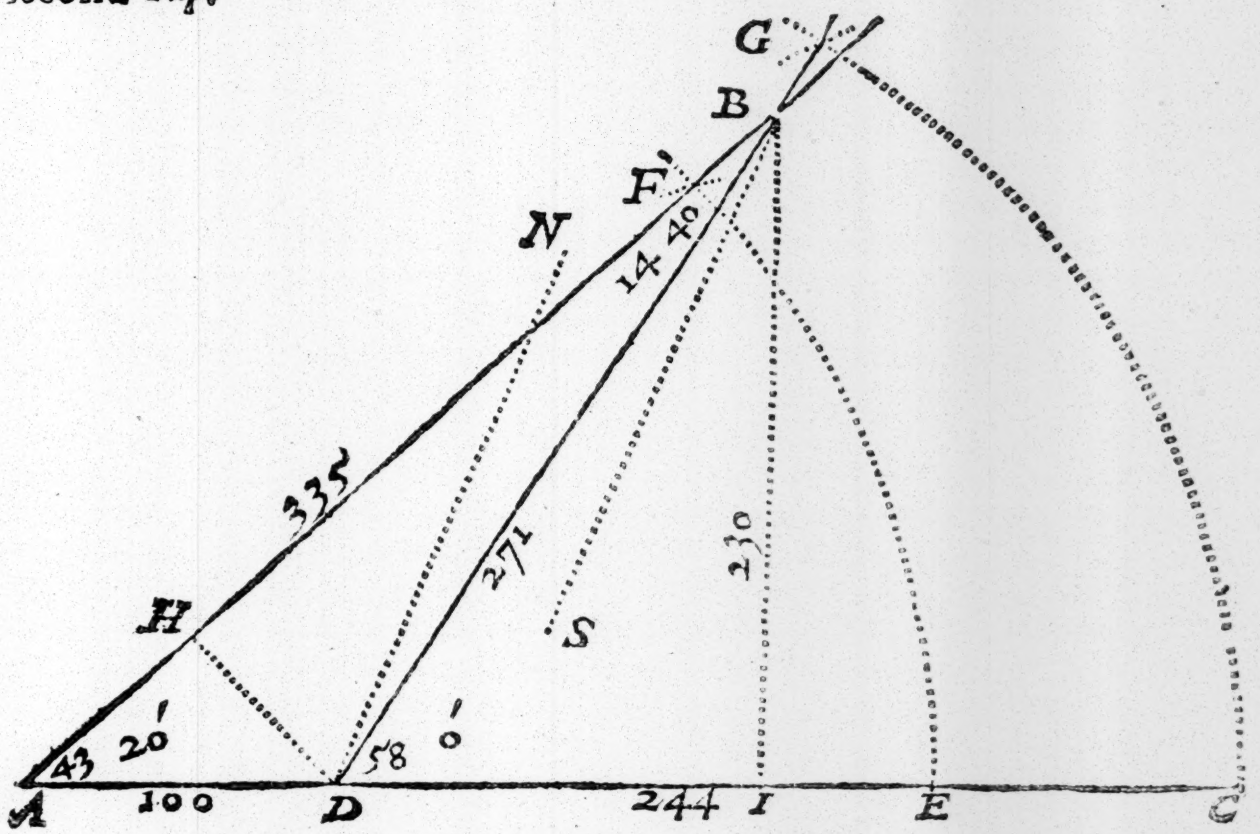
In all these there is a regard to be had to the parallax of the eye, and his height aboue the Horizon in obseruations at Sea; to the Semidiameter of the Sun, his parallax and refraction, as in the vse of other staues. And so this will be as much, or more then that which hath been heretofore performed by the *Crosse-staffe.*

CHAP.

CHAP. IIII.

The vse of the lines of equall parts ioyned with the lines of Chords.

THe lines of equall parts do serue also for protraction, as may appeare by the former *Diagrams*; but being ioyned with the lines of Chords, which I place vpon one side of the Crosse, they will farther serue for the protraction and resolution of right line triangles; whereof I will giue one example in finding of a distance at two stations otherwise then in the second *Cap.*



Let the distance required be *A B*. At *A* the first statiõ I make choise of a station line toward C, and obserue the angle *B A C* by the tangent lines, which may be 43 *gr.* 20 *m*; then hauing gon an hundred paces toward C, I make my second station at D, where suppose I find the angle *B D C* to be 58 *gr.* or

the angle *BDA* to be 122 *gr*; this being done, I may finde the distance *AB* in this maner.

1 I draw a right line *AC*, representing the station line.

2 I take 100 out of the lines of equall parts, and pricke them downe from *A* the first station vnto D the second.

3 I open my compasses to one of the chords of 60 *gr*. and setting one foote in the point *A*, with the other I describe an occult arke of a circle intersecting the station line in *E*.

4 I take out of the same line of *chords* a chord of 43 *gr*. 20 *m*. (because such was the angle at the first station) and this I inscribe into that occult arke from *E* vnto *F*, which makes the angle FAD equall to the angle obserued at the first station.

5 I describe another like arke vpon the center D, and inscribe into it a chord of 58 *gr*. from *C* vnto *G*, and draw the right line DG, which doth meet with the other line *AF* in the point *B*, and makes the angle BDC equall to the angle obserued at the second station. So the angles in the *Diagram* being equall to the angles in the field, their sides wil be also proportionall: and therefore,

6 I take out the line *AB* with my compasses, and measuring it in the same line of equall parts, from which I tooke AD, I find it to be 335, and such is the distance required.

CHAP.

CHAP. V.

The vse of the Meridian line.

1 THe Meridian line, noted with the letter *M*, may serue for the more easie diuision of the plane sea-chart, according to *Mercators* proiection. For if you shall draw parallell meridians, each degree being halfe an inch distant from other, the degrees of this meridian line on the Staffe, shall giue the like degrees for the meridians on the chart, from the Equinoctiall toward the Pole: and then if through these degrees you draw streight lines perpendicular to the meridians, they shall be parallels of latitude.

If any desire to haue the degrees of his chart larger then those which I haue put on the Staffe, he may take these and increase them in a double, or treble, or a decuple proportion at his pleasure.

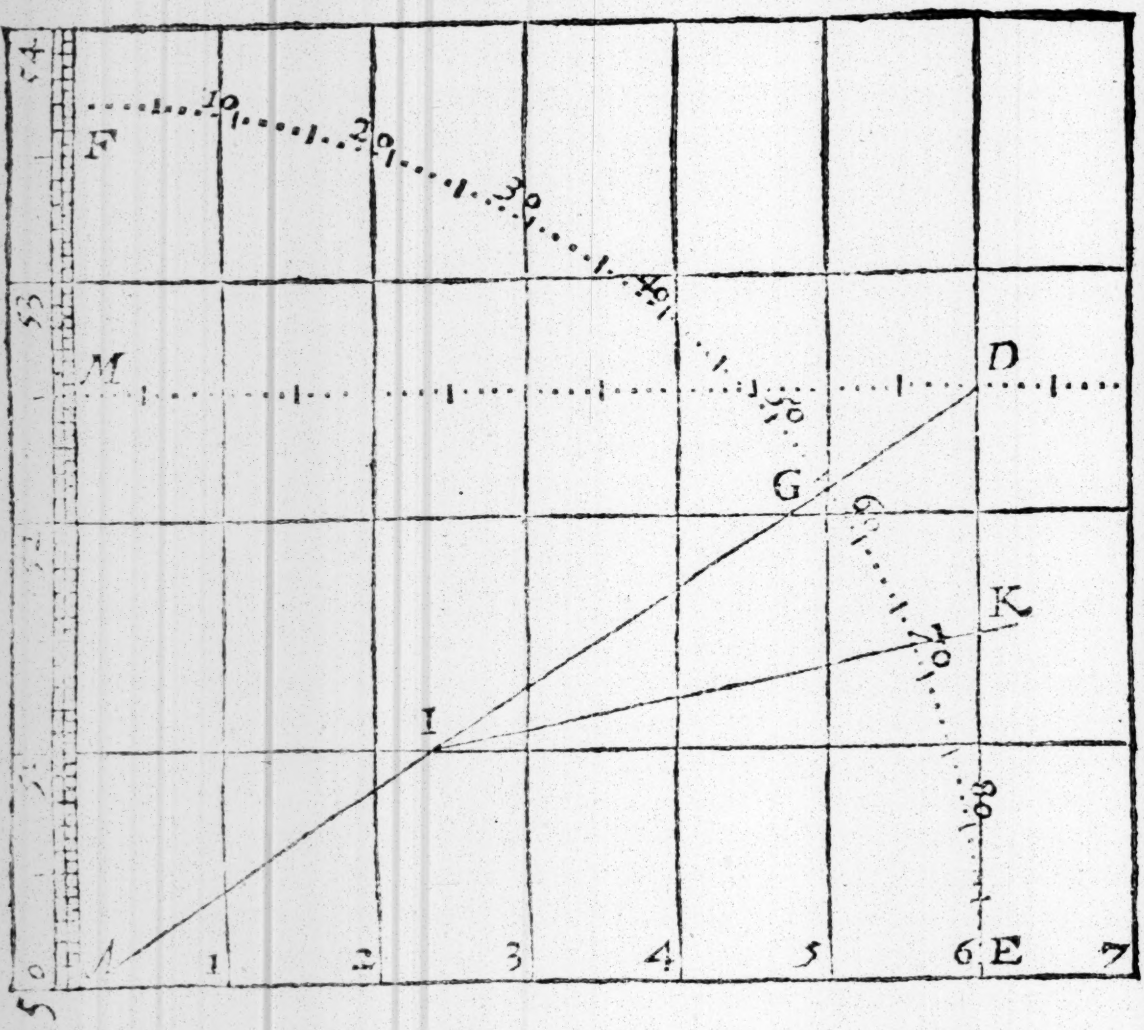
2 This *meridian* line being ioyned with the line of *chords*, may serue for the protraction & resolution of such right line triangles as concerne latitude, longitude, rumb and distance in the practise of nauigation. As may appeare by this example.

Suppose two places giuen, *A* in the latitude of 50 *gr.* D in the latitude of 52 *gr.*, the difference of longitude betweene them being 6 *gr.* and let it be required to know, first what Rumb leadeth from the one place to the other; secondly how many degrees distant they are asunder.

1 I draw a right line *A E*, representing the parallell of the place from whence I depart.

2 I take 6 *gr.* for the difference of longitude either out of the line of *inches*, allowing halfe an inch for euery degree, or out of the beginning of the *meridian* line; (for there the meridian degrees differ very little from the equinoctiall degrees) and these 6 *gr.* I pricke downe in the parallell from *A* to *E*.

3 In *A* and *E* I erect two perpendiculars, A M and E D, representing the meridians of both places.



4 I take the difference of latitude from 50 *gr.* to 52 *gr.* 30 *m.* out of the *meridian* line, and pricke it downe in the meridians from *A* vnto *M*, and from E to D, and draw the right line M D for the parallell of the second place, and the right line A D for the line of distance betweene both places: so the angle M A D shall giue the Rumb that leadeth from the one place to the other.

5 To finde the quantitie of this angle M A D, I may either make vse of the Protractor, or else of a line of *chords*, and so I open my compasses vnto one of the chords of 60 *gr.* and setting one foote in the point *A*, with the other I describe an occult arke of a circle, intersecting the meridian in *F*, and the line of distance in G; then I take the chord F G with my compasses, and measuring it in the same line of *chords* as before, I find it 56 *gr.* $\frac{1}{4}$: and such is the inclination of the

the Rumb to the meridian, which is the first thing that was required.

6 To find the quantitie of the line of distance A D, I take it out with my compasses, and measuring it in the meridian line, setting one foote beneath the lesser latitude, and the other foote as much aboue the greater latitude, I find about 4 *gr.* $\frac{1}{2}$ intercepted betweene both feet: and such is the distance vpō the Rumb, which is the second thing that was required.

But if this example were protracted according to the common Sea-chart, where the degrees of the equinoctiall and meridian are both alike; the Rumb M A D would be found to be aboue 67 *gr.* and A D the distance vpon the Rumb about 6 *gr.* $\frac{1}{2}$.

Suppose farther, that hauing set forth from *A* toward D, vpon the former Rumb of 56 *gr.* 15 *m.* *N E b E*, after the ship had runne 36 leagues, the wind changing, it ran 50 leagues more vpon the seuenth Rumb of *E b N*, whose inclination to the meridian is 78 *gr.* 45 *m.* And let it be required to know what longitude and latitude the ship is in, by pricking down the way thereof vpon the Chart.

Hauing drawne a blanke chart as before, with meridians & parallels, according to the latitude of the places proposed.

1 I would make an angle M A D of 56 *gr.* 15 *m.* for the Rumb of *N E b E*, which is done after this maner: I open my compasses to one of the *chords* of 60 *gr.* and setting one foote in the point *A*, with the other I describe an occult ark of a circle, intersecting the meridian in *F*; then I take 56 *gr.* 15 *m.* out of the same line of *chords*, and pricke them downe from *F* vnto *G*: so the right line *A G* shall be the Rumb of *N E b E*.

2 I would take 36 leagues out of the *meridian line*, extending my compasses from 50 *gr.* to 51 *gr.* 48 *m.* or rather from as much below 50 as aboue 51, and prick them downe vpon the Rumb from *A* vnto *I*; so the point *I*, shal represent the place wherein the ship was when the wind changed. And this is in the latitude of 51 *gr.* 0 *m.* and in the longitude of 2 *gr.* 21 *m.* Eastward from the meridian *A M*.

3 By the same reason, I may draw the right line *I K* for the Rumb of *E b N*, and pricke downe the distance of 50 leagues from *I* vnto *K*: so the point *K* shal represent the place whither the ship came, after the running of these 50 leagues: and this is in the latitude of 51 *gr.* 30 *m.* and in longitude 6 *gr.* 16 *m.* Eastward from the first meridian *A M*, and therefore 16 *m.* Eastward from the second meridian E D.

But if these two courses were to be pricked downe by the common sea-chart, the point *I* would fall in the latitude of 51 *gr.* 0 *m.* and the point *K* in the latitude of 51 *gr.* 30 *m.* But the longitude of *I* would be onely 1 *gr.* 30 *m.* and the longitude of *K* onely 3 *gr.* 57 *m.* which is 33 *m* Westward from the meridian of the place to which the ship was bound.

Such is the difference betweene both these charts.

CHAP. VI.

The vse of the line of Numbers.

1 *Hauing two numbers giuen to find a third in continuall proportion, a fourth, a fift, and so forward.*

EXtend the compasses from the first number vnto the second; then may you turne them, from the second to the third, and from the third to the fourth, and so forward.

Let the two numbers giuen be 2 and 4. Extend the compasses from 2 to 4, then may you turne them from 4 to 8, and from 8 to 16, and from 16 to 32, and from 32 to 64, and from 64 to 128.

Or if the one foote of the compasses being set to 64, the other fall out of the line, you may set it to another 64 nearer the beginning of the line, and there the other foot will reach to 128, and from 128 you may turne them to 256, and so forward.

Or if the two first numbers giuen were 10 and 9: extend the compasses from 10 at the end of the line, backe vnto 9, then may you turne them from 9 vnto 8.1, and from 8.1

vnto

vnto 7.29. And so if the two first numbers giuen were 1 and 9, the third would be found to be 81, the fourth 729, with the same extent of the compasses.

In the same maner, if the two first numbers were 10 and 12, you may finde the third proportionall to be 14.4, the fourth 17.28. And with the same extent of the compasses, if the two first numbers were 1 and 12, the third would be found to be 144, and the fourth to be 1728.

2 *Hauing two extreme numbers giuen, to find a meane proportionall between them.*

Diuide the space betweene the extreme numbers into two equall parts, and the foote of the compasses will stay at the meane proportionall. So the extreme numbers giuen being 8 and 32, the meane betweene them will be found to be 16, which may be proued by the former *Prop.* where it was shewed, that as 8 to 16, so are 16 to 32.

3 *To find the square roote of any number giuen.*

The square roote is alwayes the meane proportionall betweene 1 and the number giuen, and therefore to be found by diuiding the space betweene them into two equall parts. So the roote of 9 is 3, and the roote of 81 is 9, and the roote of 144 is 12.

4 *Hauing two extreme numbers giuen, to find two meane proportionals between them.*

Diuide the space betweene the two extreme numbers giuen, into three equall parts. As if the extreme numbers giuen were 8 and 27, diuide the space betweene them into three equall parts, the feet of the compasses will stand in 12 and 18.

5 *To find the cubique roote of a number giuen.*

The cubique roote is alwayes the first of two meane pro-

portionals betweene 1 and the number giuen, and therefore to be found by diuiding the ſpace betweene them into three equall parts.

So the roote of 1728 will be found to be 12. The roote of 17280 is almoſt 26: and the roote of 172800 is almoſt 56.

6 To multiply one number by another.

Extend the compaſſes from 1 to the multiplicator; the ſame extent applied the ſame way, ſhall reach from the multiplicand to the product.

As if the numbers to be multiplied were 25 and 30: either extend the compaſſes from 1 to 25, and the ſame extent will giue the diſtance from 30 to 750; or extend them from 1 to 30, and the ſame extent ſhall reach from 25 to 750.

7 To diuide one number by another.

Extend the compaſſes from the diuiſor to 1, the ſame extent ſhall reach from the diuidend to the quotient.

So if 750 were to be diuided by 25, the quotient would be found to be 30.

8 Three numbers being giuen to find a fourth proportionall.

This golden rule, the moſt vſefull of all others, is performed with like eaſe. For extend the compaſſes from the firſt number to the ſecond, the ſame extent ſhall giue the diſtance from the third to the fourth.

As for example, the proportion between the diameter and the circumference, is ſaid to be ſuch as 7 to 22: if the diameter be 14, how much is the circumference? Extend the compaſſes from 7 to 22, the ſame extent ſhall giue the diſtance from 14 to 44: or extend them from 7 to 14, and the ſame extent ſhall reach from 22 to 44.

Either of theſe wayes may be tried on ſeuerall places of this

this line; but that place is best, where the feete of the compasses may stand nearest together.

9 Three numbers being giuen to finde a fourth in a duplicated proportion.

This proposition concernes questions of proportion betweene *lines* and *superficies*; where if the denomination be of lines, extend the compasses from the first to the second number of the same denomination: so the same extent being doubled, shall giue the distance from the third number vnto the fourth.

The diameter being 14, the content of the circle is 154: the diameter being 28, what may the content be? Extend the compasses from 14 to 28, the same extent doubled will reach from 154 to *616*. For first it reacheth from 154 vnto 308; and turning the compasses once more, it reacheth from 308 vnto *616*: and this is the content required.

But if the first denomination be of the superficiall content, extend the compasses vnto the halfe of the distance, betweene the first number and the second of the same denomination: so the same extent shall giue the distance from the third to the fouth.

The content of a circle being 154, the diameter is 14: the content being *616*, what may the diameter be? Diuide the distance betweene 154 and *616* into two equall parts, then set one foote in 14, the other will reach to 28 the diameter required.

10 Three numbers being giuen to find a fourth in a triplicated proportion.

This proposition concerneth questions of proportion betweene *lines* and *solids*; where if the first denomination be of lines, extend the compasses from the first number to the second of the same denomination: so the extent being tripled, shall giue the distance frō the third number vnto the fourth.

Suppose the diameter of an iron bullet being 4 inches, the weight of it was 9 ℔: the diameter being 8 inches, what may the weight be? Extend the compasses from 4 to 8, the same extent being tripled, will reach from 9 vnto 72. For first it reacheth from 9 vnto 18; then from 18 to 36; thirdly from 36 to 72. And this is the weight required.

But if the first denomination shall be of the Solid content, or of the weight, extend the compasses to a third part of the distance betweene the first number and the second of the same denomination: so the same extent shal giue the distance from the third number vnto the fourth.

The weight of a cube being 72 ℔, the side of it was 8 inches: the weight being 9 ℔, what may the side be? Diuide the distance betweene 72 and 9, into three equall parts; then set one foote to 8, the other will reach to 4, the side required.

CHAP. VII.

The vse of the lines of artificiall Sines.

THis line of *sines* hath such vse in finding a fourth proportionall, as the ordinary *Canon* of *Sines*: and the maner of finding it, is alwayes such as in this example.

As the sine of 30 *gr.* vnto the sine of 52 *gr.*
So the sine of 38 *gr.* to a fourth sine.

Extend the compasses in the line of *sines* from 30 *gr.* vnto 52 *gr*; the same extent shall giue the distance from 38 *gr.* vnto 76 *gr.* Or extend them from 30 *gr.* vnto 38 *gr.* the same extent will reach from 52 *gr.* vnto 76 *gr.* which is the fourth proportionall sine required.

And thus may the rest of all sinical proportions be wrought two wayes. The minutes which are wanting in the first degree, may be supplied by the line of *Numbers*.

CHAP.

CHAP. VIII.

The vse of the line of artificiall Tangents.

THis line of *Tangents* hath like vse, but commonly ioyned with the line of *sines*: the maner of working by it, may appeare by this example.

As the Tangent of 38 *gr*. 30 *m*.
is to the Tangent of 23 *gr*. 30 *m*.
So the Sine of 90 *gr*.
to a fourth Sine.

This *Prop*. and such others vpon two lines, may be wrought two wayes. For extend the compasses from the Tangent of 38 *gr*. 30 *m*. to the Tangent of 23 *gr*. 30 *m*; the same extent shall giue the distance from the sine of 90 *gr*. to the sine of 33 *gr*. 8 *m*. Or else extend them from 38 *gr*. 30 *m*. in the Tangents vnto 90 *gr*. in the line of *sines*; the same extent from the Tangent of 23 *gr*. 30 *m*. shall reach to the sine of 33 *gr*. 8 *m*. which is the fourth proportionall sine required.

And this crossework in many cases is the better, in regard the tangents which should passe on from 40 *gr*. to 50 *gr*. and so forward, do turne backe at 45 *gr*. These two lines of *Sines* and *Tangents*, may serue for the resolution of all sphericall triangles, according to those Canons which I haue set downe in the vse of the *Sector*.

Or if at any time one meete with a *secant*, let him account the sine of 80 *gr*. for a *secant* of 10 *gr*. and the sine of 70 *gr*. for a *secant* of 20 *gr*. and so take the sine of the complement in stead of the *secant*. As if the proposition were,

As the Radius to the secant of 51 *gr*. 30 *m*.
So the sine of 23 *gr*. 30 *m*. to a fourth sine.

Extend the compasses from the Radius that is the sine of 90 *gr*. to the sine of 38 *gr*. 30 *m*. the same extent will giue the distance from the sine of 23 *gr*. 30 *m*. both to the sine of 14 *gr*.

22 *m.* and to the sine of 39 *gr.* 50 *m.* But in this case, the sine of 39 *gr.* 50 *m.* is the fourth required. For the first number being lesse then the second, that is, the Radius lesse then the secant, the sine of 23 *gr.* 30 *m.* which is the third, must also be lesse then the fourth.

CHAP. IX.

The vse of the line of Sines and Tangents ioyned with the line of numbers.

THe lines of *sines* and *tangents* haue another like vse ioyned with the line of *numbers*, especially in the resolution of right line triangles, where the angles are measured by degrees and minutes, and the sides measured by absolute numbers, whereof I will set downe these propositions.

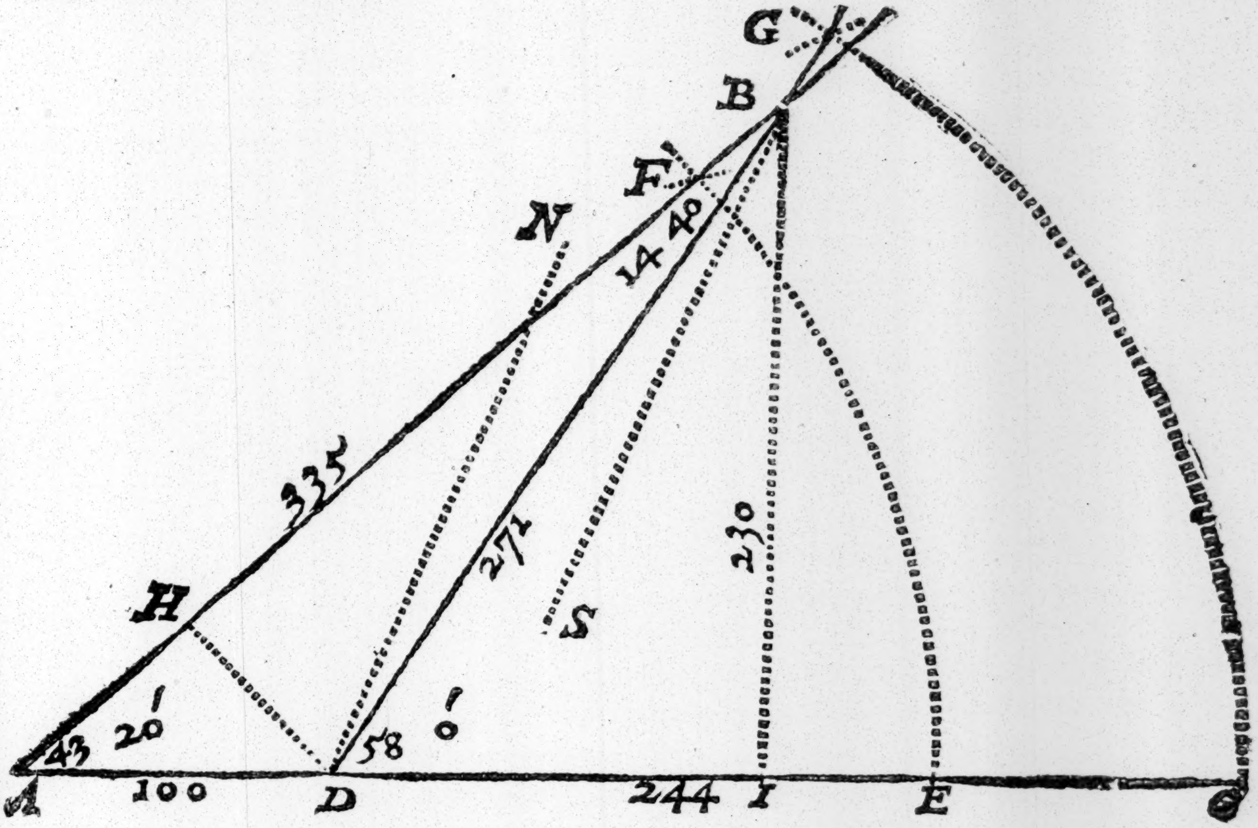
1 *Hauing three angles and one side, to find the two other sides.*

As the side of the angle opposite to the side giuen,
is to the number belonging to that side giuen:
So the sine of the angle opposite to the side required,
to the number belonging to the side required.

As in the example of the fourth *Cap.* of this booke, where knowing the distance betweene two stations at *A* and *D* to be 100 paces, the angle *B A C* to be 43 *gr.* 20 *m.* and the angle *B D C* to be 58 *gr.* it was required to find the distance *A B.*

First hauing these two angles, I may find the third angle *A B D* to be 14 *gr.* 40 *m.* either by substraction or by complement vnto 180. Then in the triangle *B A D*, I haue three angles, and one side, whereby I may find both *A B* and *D B.* I know the angle *A B D* opposite to the measured side *A D* to be 14 *gr.* 40 *m.* and the angle *A D B* opposite to the side required, to be 122 *gr:* wherefore I extend the compasses in the

the line of *sines* from 14 *gr.* 40 *m.* vnto 122 *gr.* or (which is all one) to 58 *gr.* (for after 90 *gr.* the sine of 80 *gr.* is also the sine of 100 *gr.* and the sine of 70 *gr.* the sine of 110 *gr.* and so in the rest) so shall I find the same extent to reach in the line of *numbers*, from 100 vnto 335. And such is the distance required betweene *A* and *B*.



In like maner if I extend my compasses from the sine of 14 *gr.* 40 *m.* to the sine of 43 *gr.* 20 *m.* the same extent will reach in the line of *numbers* from 100 to 271. And such is the distance betweene D and B.

Or in crosse worke, I may extend the compasses from 14 *gr.* 40 *m.* in the *sines*, vnto 100 parts in the line of *numbers*: so the same extent will giue the distance from 58 *gr.* to 335 parts, and from 43 *gr.* 20 *m.* to 271 parts.

2 *Hauing two sides giuen, and one angle opposite to either of these sides, to find the other two angles and the third side.*

As the side opposite to the angle giuen,
is to the sine of the angle giuen:
So the other side giuen,
to the sine of that angle to which it is opposite.

So in the former triangle, hauing the two sides *AB* 335 paces and A D 100 paces, and knowing the angle A D B, which is opposite to the side *AB*, to be 122 *gr.* I may find the angle A B D, which is opposite to the other side A D. For if I extend the compasses from 335 to 100 in the line of *numbers*, I shall finde the same extent to reach in the line of *sines* from 122 *gr.* to 14 *gr.* 40 *m*; and therefore such is the angle A B D.

Then knowing these two angles ABD and ADB, I may find the third angle B A D either by subtraction or by complement to 180, to be 43 *gr.* 20 *m*; and hauing three angles and two sides, I may well find the third side DB, by the former *Prop.*

This may be done more readily by crosse worke. For if I extend the compasses from 335 parts, in the line of *numbers*, to the sine of 122 *gr.* the same extent wil reach from 100 parts to the sine of 14 *gr.* 40 *m.* and backe from 43 *gr.* 20 *m.* to 272 parts; and such is the third side DB.

3 *Hauing two sides and the angle between them, to find the two other angles and the third side.*

If the angle contained betweene the two sides be a right angle, the other two angles will be found readily by this canon.

As the greater side giuen,
is to the lesser side:

So

So the tangent of 45 *gr.*
to the tangent of the lesser angle.

So in the rectangle triangle *AIB*, knowing the side *AI* to be 244, and the side *IB* to be 230: if I extend the compasses from 244 to 230 in the line of *numbers*, the same extent will reach from 45 *gr.* to about 43 *gr.* 20 *m.* in the line of *tangents*; and such is the lesser angle *BAI*, and the complement 46 *gr.* 40 *m.* shewes the greater angle *ABI*. The angles being knowne, the third side A B may be found by the first *Prop.*

So likewise in the example of the third *Cap.* of this booke, concerning taking of angles by the line of *inches*, where the parts intercepted on the Staffe being 20 *inches*, and the parts on the Crosse 9 *inches*, it was required to find the angle of altitude. For I may extend the compasses in the line of *numbers*, from 20 vnto 9, the same extent will reach in the line of *tangents*, from 45 *gr.* to 24 *gr.* 14 *m.* Or in the crosse worke, I may extend the compasses from 20 parts in the line of *numbers* to the tangent of 45 *gr*; the same extent shall giue the distance from 9 parts vnto the tangent of 24 *gr.* 14 *m.* And such is the angle of altitude required.

But if it be an oblique angle that is contained betweene the two sides giuen, the triangle may be reduced into two rectangle triangles, and then resolued as before.

As in the triangle A D B, where the side A B is 335, and the side A D 100, and the angle B A D 43 *gr.* 20 *m*: if I let downe the perpendicular DH vpon the side A B, I shal haue two rectangle triangles, AHD, DHB; and in the rectangle AHD, the angle at *A* being 43 *gr.* 20 *m.* the other angle ADH will be 46 *gr.* 40 *m*; and with these angles and the side *AD*, I may find both *AH* and DH, by the first *Prop.* Then taking *AH* out of *AB*, there remaines H B for the side of the rectangle DHB; and therefore with this side H B and the other side D H, I may find both the angle at B, and the third side D B, as in the former part of this *Prop.*

Or I may find the angles required, without letting downe any perpendicular. For

As the summe of the sides,
is to the difference of the sides:
So the tangent of the halfe summe of the opposite angles,
to the tangent of half the difference between those angles.

As in the former triangle *A D B*, the summe of the sides *A B*, *A D*, is 435, and the difference betweene them 235; the angle contained 43 *gr*. 20 *m*; and therefore the summe of the two opposite angles 136 *gr*. 40 *m*. and the halfe summe 68 *gr* 20 *m*. Hereupon I extend the compasses in the line of *numbers* from 455 to 235, and I find them to reach in the line of *tangents* from 68 *gr*. 20 *m*. vnto 53 *gr*. 40 *m*; and such is the halfe difference betweene the opposite angles at *B* and *D*. This halfe difference being added to the halfe summe, doth giue 122 *gr*. for the greater angle *A D B*: and being subtracted, it leaueth 14 *gr*. 40 *m*. for the lesser angle *ABD*. Then the three angles being knowne, the third side B D may be found by the first *Prop*.

4 *Hauing the three sides of a right line triangle, to find the perpendicular and the three angles.*

Let one of the three sides giuen be the base, but rather the greater side, that the perpendicular may fall within the triangle; then gather the summe, and the difference of the two other sides, and the proportion will hold.

As the base of the triangle,
is to the summe of the sides:
So the difference of the sides
to a fourth, which being taken forth of the base, the perpendicular shal fall on the middle of the remainder.

As in the former triangle ADB, where the base AB is 335, the summe of the sides AD and DB 371, and the difference of them 171. If I extend the compasses in the line of *numbers* from 335 vnto 371, I shall find the same extent to reach from 171 vnto 189 4. This fourth number I take out of the

base

base 335.0, and the remainder is 145.6, the halfe whereof is 72.8, and doth shew the place *H*, where the perpendicular shall fall, from the angle D, vpon the base *A B*, diuiding the former triangle ADB into two right angle triangles, DHA and DHB, in which the angles may be found by the former part of the third *Prop.* And this may suffice for right line triangles. But for the more easie protraction of these triangles, I will set downe one proposition more concerning *chords*.

5 *Hauing the semidiameter of a circle, to find the chords of euery arke.*

As the sine of 30 *gr.*
to the sine of halfe the arke proposed:
So is the semidiameter of the circle giuen,
to the chord of the same arke.

As if in protracting the former triangle ADB, it were required to find the length of a chord of 43 *gr.* 20 *m.* agreeing to the semidiameter *A E*, which is knowne to be 3 *inches*. The halfe of 43 *gr.* 20 *m.* is 21 *gr.* 40 *m*; wherefore I extend the compasses from the sine of 30 *gr.* to the sine of 21 *gr.* 40 *m.* and I finde the same extent to reach in the line of *numbers* from 3.000 *parts* to 2.215; which shewes, that the semidiameter being 3 inches, the chord of 43 *gr.* 20 *m.* will be 2 *inches* and 215 *parts* of 1000.

In like maner the chord of 58 *gr.* agreeing to the same semidiameter, would be found to be 2 *inches* and 909 *parts*. For the halfe of 58 being 29; if I extend the compasses in the line of *sines* from 30 *gr.* to 29 *gr.* the same extent will reach in the line of *numbers* from 3.000. vnto 2.909.

Or in crosse worke, if I extend the compasses from the *sine* of 30 *gr.* to 3.000 in the line of *numbers*, I shall find the same extent to reach from 21 *gr.* 40 *m.* to 2.215 *parts*, and from 29 *gr.* to 2.909 *parts*, and from 7 *gr.* 20 *m.* to 765 *parts*; for the chord of 14 *gr.* 40 *m.* for the third angle ABD.

CHAP. X.

The vse of the line of versed sines.

THis line of *versed sines* is no necessary line. For all triangles, both right lined and sphericall, may be resolued by the three former lines of ***numbers***, *sines* and ***tangents***; yet I thought good to put it on the Staffe for the more easie finding of an angle hauing three sides, or a side hauing three angles of a sphericall triangle giuen.

Suppose the three sides to be, one of them 110 *gr.* the other 78 *gr.* and the third 38 *gr.* 30 *m.* and let it be required to find the angle, whose base is 110 *gr.*

I first adde them together, and from halfe the summe subtract the base, noting the difference after this maner.

The base	110 *gr.*	0 *m.*
The one side	78	0
The other side	38	30
The summe of all three	226	30
The halfe summe	113	15
The difference	3	15

This done, I come to the Staffe, and extend the compasses from the sine of 90 *gr.* to the sine of 78 *gr.* which is one of the sides; and applying this extent from the sine of the other side 38 *gr.* 30 *m.* I find it to reach to a fourth sine, about 37 *gr.* 30 *m.* From this fourth sine of 37 *gr.* 30 *m.* I extend the compasses again, to the sine of the halfe summe 113 *gr.* 15 *m.* (which is all one with the sine of 66 *gr.* 45 *m.*) and this second extent wil reach from the sine of the difference 3 *gr.* 15 *m.* to the sine of 4 *gr.* 54 *m.* Ouer against this sine you shal find 146 *gr.* in the line of *versed sines*; and such is the angle required.

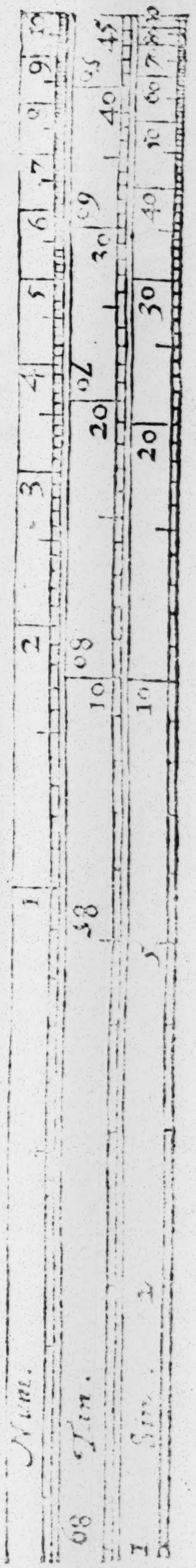
THE

THE SECOND BOOKE

Of the vse of the former lines of proportiõ, more particularly exemplified in seuerall kinds.

THe former booke containing the generall vse of each line of proportion, may be sufficient for all those which know the rule of *Three*, and the doctrine of triangles.

But for others, I suppose it would be more difficult to find either the declination of the Sunne, or his amplitude, or the like, by that which hath been said in the vse of the line of *sines*, vnlesse they may haue the particular proportions, by which such propositions are to be wrought. And therefore for their sakes I haue adioyned this second booke, containing seuerall proportions for propositions of ordinary vse, and set them down in such order, that the Reader considering which is the first of the three numbers giuen, may easily apply them to the Sector, and also resolue them by Arithmetique, beginning with those which require help onely of the line of *numbers*.



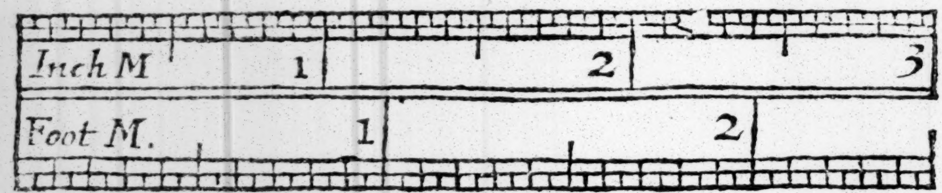
CHAP. I.

The vse of the line of Numbers in broade measure, such as boord, glasse, and the like.

THe ordinary measure for bredth and length are feete and inches, each foote diuided into 12 inches, and euery inch into halues & quarters,

ters, which being parts of seuerall denominations, doth breed much trouble both in arithmetique and the vse of instruments.

For the auoiding whereof, where I may preuaile I giue this counsell, that such as are delighted in measure would vse seuerall lines, first a line of inch measure, wherein euery inch may be diuided into 10 or 100 parts; secondly a line of foote measure, wherein euery foote may be diuided into 100 or 1000 parts, both which lines may be set on the same side of a two foote ruler, after this or the like maner.



Then if they be to giue the content of any superficies or solid in inches, they may measure the sides of it by the line of inches and parts of inches; but if they be to giue the content in feete, it would be more easie for them to measure those sides by the foote line and his parts.

For example, let the length of a plane be 30 inches, and the bredth 21 inches and $\frac{6}{10}$ of an inch; this length multiplied into the bredth, would giue the content to be 648 inches: but if I were to find the content of the same plane in feet, I would measure the sides of it by the foote line and his parts; so the length would proue to be 2 feete $\frac{50}{100}$, and the bredth 1 foote $\frac{80}{100}$, and the length multiplied by the bredth, cutting off the foure last figures, for the foure figures of the parts, would giue the content to be 4. 5000, which is 4 foote and 5000 parts, of a foot being diuided into 10000 parts.

21.6	2.50
30.0	1.80
648.00	20000
	250
	4.5000

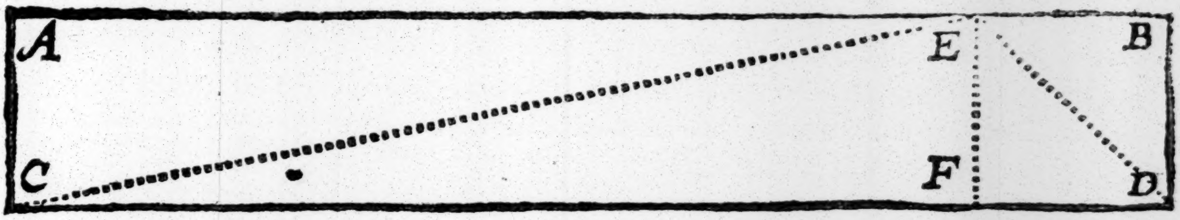
The

The like reason holdeth for yards and elnes, and all other measures diuided into 10, 100, or 1000 parts.

This being presupposed, the worke will be more easie both by arithmetique and the line of *numbers*, as may appeare by these propositions.

1 *Hauing the bredth and length of any oblong superficies giuen in inch-measure, to finde the content in inches.*

As 1 inch vnto the bredth in inches:
So the length in inches vnto the content in inches.



Suppose in the plane AD, the bredth *A C* to be 30 inches, and the length *A B* to be 183 inches; extend the compasses from 1 vnto 30, the same extent will reach from 183 vnto 5490; or extend them from 1 vnto 183, the same extent will reach from 30 vnto 5490. So both wayes the content required is found to be 5490 inches.

As 1 vnto 30: so are 183 vnto 5490.

2 *Hauing the length and bredth of any oblong superficies giuen in inches, to finde the content in feete.*

As 144 inches vnto the bredth in inches:
So the length in inches vnto the content in feete.

And thus in the former plane A D, working as before, the content will be found to be 38.125, which is 38 foote and $\frac{1}{8}$ of a foote.

As 144 vnto 30: so are 183 vnto 38.125.

3 *Hauing the length and bredth of any oblong superficies giuen in foote measure, to finde the content in feete.*

As 1 foote vnto the bredth in foote measure:
So the length in feete vnto the content in feete.

And thus in the former plane AD, the bredth will be 2 foote 50 parts, and the length 15 foot 25 parts; then working as before, the content will be found to be 38.125.

As 1 vnto 2.50 : so are 15.25 vnto 38.125.

4 *Hauing the bredth of any oblong superficies giuen in inches, and the length in foote measure, to find the content in feet.*

As 12 inches to the bredth in inches:
So the length in feet to the content in feet.

So also in the former plane, the content will be found to be 38.125.

As 12 vnto 30 : so are 15.25 vnto 38.125.

5 *Hauing the bredth of an oblong superficies giuen in inches, to find the length of a foot superficiall in inch measure.*

As the bredth in inches, vnto 144 inches:
So 1 foot vnto the length in inch measure.

So the bredth being 30 inches, the length of a foot wil be found to be 4 inches 80 parts.

As 30 vnto 144 : so are 1 vnto 4.80.

6 *Hauing the bredth and length of an oblong superficies giuen in feet, to find the length of a foot superficiall in foot measure.*

As the bredth in foot measure to 1 foot:
So the number of feet to the length in foot measure.

So

So the bredth being 2 foot 50 parts, the length of a foot will be found to be 40 parts, the length of 2 feete 80 parts, and the length of 3 feet 1 foot 20 parts, &c.

As 250 vnto 1: so are 1 vnto 0.40.

7 *Hauing the length and bredth of an oblong superficies, to find the side of a square equall to the oblong.*

Diuide the space betweene the length and the bredth into two equall parts, and the foot of the compasses will stay at the side of the square.

So the length being 183 inches, and the bredth 30 inches, the side of the square will be found to be almost 74 inches and 10 parts of 100.

Or the bredth being 2 foot and 50 parts, the length 15 foot and 25 parts, the side of the square wil be found to be about 6 feet and 17 parts.

As 30 vnto 74.10: so are 74.10 vnto 183.027.

And as 2.50 vnto 6.174: so are 6.174 vnto 15.247.

8 *Hauing the diameter of a circle, to find the side of a square equall to that circle.*

As 10000 to the diameter:

So 8862 vnto the side of the square.

So the diameter of a circle being 15 inches, the side of the square will be found about 13 inches and 29 parts.

As 10000 vnto 8862: so are 15 vnto 13.29.

9 *Hauing the circumference of a circle to find the side of a square equall to the same circle.*

As 10000 to the circumference:

So 2821 to the side of the square.

So the circumference of a circle being 47 inches 13 parts, the side of the square will be about 13 inches 29 parts.

As 10000 vnto 2821: so are 47.13 vnto 13.29.

10 Hauing the diameter of a circle, to find the circumference.

11 Hauing the circumference of a circle, to find the diameter.

As 1000 to the diameter:
So 3142 to the circumference.

So the diameter being 15 inches, the circumference will be found about 47 inches 13 parts: or the circumference being 47.13, the diameter will be 15.

CHAP. II.

The vse of the line of Numbers in the measure of land by perches and acres.

1 Hauing the bredth and length of an oblong superficies giuen in perches, to find the content in perches.

As 1 perch to the bredth in perches:
So the length in perches to the content in perches.

So in the former plane *A D*, if the bredth *A C* be 30 perches, and the length *A B* 183 perches, the content will be found to be 5490 perches.

2 Hauing the length and bredth of an oblong superficies giuen in perches, to find the content in acres.

As 160 to the bredth in perches:
So the length in perches to the content in acres.

So in the former plane *A D*, the content will be found to be 34 acres, and 31 centesms or parts of an 100.

As 160 vnto 30: so are 183 vnto 34.31.

3 *Hauing*

3 *Hauing the length and bredth of an oblong superficies giuen in chaines, to find the content in acres.*

It being troublesome to diuide the content in perches by 160, we may measure the length and bredth by chaines, each chaine being 4 perches in length, and diuided into 100 links, then will the worke be more easie in arithmetique. For

As 10 to the content in chaines:
So the length in chaines to the content in acres.

And thus in the former plane AD, the bredth *A C* will be 7 chaines 50 links, and the length *A B* 45 chaines 75 links; then working as before, the content will be found as before, 34 acres 31 parts.

4 *Hauing the perpendicular and base of a triangle giuen in perches, to find the content in acres.*

If the perpendicular go for the bredth, and the base for the length, the triangle will be the halfe of the oblong. As the triangle C E D is the halfe of the oblong AD, whose content was found in the former *Prop.* Or without halfing,

As 320 to the perpendicular:
So the base to the content in acres.

So in the triangle C E D, the perpendicular being 30, and the base 183, the content will be found to be about 17 acres and 15 parts.

5 *Hauing the perpendicular and base of a triangle giuen in chaines, to find the content in acres.*

As 20 to the perpendicular:
So the base to the content in acres.

And so in the triangle C E D, the perpendicular *E F* being

ing 7.50, and the base C D 45.75, the content will be found as before to be about 17 acres 15 parts.

6 *Hauing the content of a superficies after one kind of perch, to find the content of the same superficies according to another kind of perch.*

As the length of the second perch
to the length of the first perch:
So the content in acres to a fourth number;
and that fourth to the content in acres required.

Suppose the plane A D measured with a chaine of *66* feet, or with a perch of 16 feete and an halfe, contained 34 acres 31 parts; and it were demanded how many acres it would containe if it were measured with a chaine of 18 foot to the perch: these kind of propositions are wrought by the backward rule of *three*, after a duplicated proportion. Wherefore I extend the compasses from *16*.5 vnto 18.0, and the same extent doth reach backward, first from 34.31 to 31.45, and then from 31.45 to 28.84, which shewes the content to be 28 acres 84 parts.

7 *Hauing the plot of a plane with the content in acres, to find the scale by which it was plotted.*

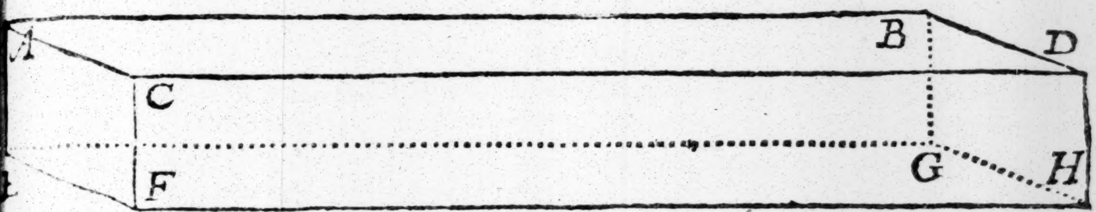
Suppose the plane A D contained 34 acres 31 centesimes; if I should measure it with a scale of 10 in the inch, the length AB would be 38 chaines and about 12 centesimes, and the bredth *AC* 6 chaines and 25 centesimes; and the content would be found by the third *Prop.* of this Chapter, to be about 23 acres 82 parts, whereas it should be 34 acres 31 parts.

Wherefore I diuide the distance betweene 23,82, and 34 31, vpon the line of *numbers* into two equall parts; then setting one foote of the compasses vpon 10, my supposed scale, I find the other to extend to 12, which is the scale required.

CHAP.

CHAP. III.

The vse of the line of Numbers in solid measure, such as stone, timber, and the like.



1 ***Hauing the side of a square equall to the base of any solid giuen in inch measure, to find the length of a foot solid in inch measure.***

THe side of a square equall to the base of a solid, may be found by diuiding the space betweene the length and bredth into two equall parts, as in the 7 *Prop.* of broad measure. Then

As the side of the square in inches to 41.57:
So is 1 foot to a fourth number;
and that fourth to the length in inches.

So in the solid *A H*, the side of the square equall to the base *E C*, being about 25 inches 45 parts, the length of a foot solid will be found about 2 inches 67 parts, and the length of two foot solid 5 inches 33 parts.

As 25.45 vnto 41.57 : so 1.00 vnto 1.63:
and so are 1.63 vnto 2.67.

Hauing the side of a square equall to the base of any solid giuen in foot measure, to find the length of a foot solid in foot measure.

As the side of the square in feet vnto 1:
So is 1 vnto a fourth number;
And that fourth to the length in foot measure.

So in the solid *A H*, the side of the square equall to the

base

base *E C*, being about 2 foote 120 parts, the length of a foot solid will be found about 222 parts of a foot.

As 2.120 vnto 1.000: so 1.000 vnto 0.471: and so are 471 vnto 222.

3 ***Hauing the bredth and depth of a squared solid giuen in foot measure, to find the length of a foot solid in foot measure.***

As 1 vnto the bredth in foot measure:
So the depth in feet to a fourth number;
which is the content of the base in foot measure. Then
As this fourth number vnto 1:
So 1 vnto the length in foot measure.

So in the solid *A H*, the bredth being 2 foot 50 parts, the depth 1 foot 80 parts, the content of the base *E C* will be found 4 foot 50 parts, and the length of one foot solid about 222 parts, the length of two foot solid about 444 parts of 1000.

As 1.00 vnto 2.50: so are 1.80 vnto 4.50.
As 4.50 vnto 1.00: so 1.000 vnto 0.222.

4 ***Hauing the bredth and depth of a squared solid giuen in inches, to find the length of a foot solid in inch measure.***

As 1 hath to the bredth in inches:
So the depth in inches to a fourth number;
which is the content of the base in inches. Then
As this fourth number vnto 1728:
So 1 vnto the length of a foot in inch measure.

So in the solid *A H*, the bredth *A C* being 30 inches, and the depth *A E* 21 inches 60 parts, the content of the base *E C* will be found to be 648 inches, and the length of a foot solid about 2 inches 67 parts.

As 1 vnto 21.6: so 30 vnto 648:
As 648 vnto 1728: so 1 vnto 2.667.

Or as 12 to the bredth in inches:
So the depth in inches to a fourth number.

As this fourth number to 144:
So 1 vnto the length of a foot solid in inch measure.

So in the solid *AH*, the bredth being 30 inches, the depth 21 inches 6 parts, the fourth number will be found to be 54 and the depth of a foot solid 2 inches 67 parts.

As 12 vnto 21.6: so 30 vnto 54.
As 54 vnto 144: so 1 vnto 2.667.

5 *Hauing the side of a square equall to the base of any solid, and the length thereof giuen in inch measure, to find the content thereof in feet.*

As 41.57 to the side of the square in inches:
So the length in inches to a fourth number;
and that fourth to the content in foot measure.

So in the solid *AH*, the length *AB* being 183 inches, and the side of the square equall to the base *EC* about 25 inches 45 parts, the fourth number will be found about 112, and the whole solid content about 68 feet 62 parts.

As 41.57 vnto 25.45: so 183 vnto 112:
and so are 112 vnto 68.62.

6 *Hauing the side of a square equall to the base of any solid, and the length thereof giuen in foot measure, to find the content thereof in feet.*

As 1 to the side of the square in foot measure.
So the length in feet to a fourth number;
and that fourth to the content in foot measure.

So in the former solid *A H*, the side of the square equall to the base *A E*, being about 2 foot 12 parts, and the length *A B* 15 foot 25 parts, the conent will be found to be about 68 foot 62 parts.

As 1 vnto 2.12: so 15.25 vnto 32.35:
and so are 32.35 vnto 68.62.

7 *Hauing the side of a square equall to the base of any solid giuen in inch measure, & the length of the solid giuen in foot measure, to find the content thereof in feete.*

As 12 to the side of the square giuen in inches:
So the length in feet to a fourth number;
and that fourth to the content in foot measure.

So in the former solid *A H*, the side of the equall square being 25 inches 45 parts, the content will be found to be about 68 feet 62 parts.

As 12 vnto 25.45: so 15.25 vnto 32.35:
and so are 32.35 vnto 68.62.

8 *Hauing the length, bredth and depth of a squared solid giuen in inches, to find the content in inches.*

As 1 vnto the bredth in inches:
So the depth in inches vnto the base in inches. Then

As 1 vnto the base:
So the length in inches vnto the solid content in inches.

So in the solid *A H*, whose bredth *A C* is 30 inches, the depth *A E* 21 inches and 6 parts of 10, and length *A B* 183, the content of the base *E C* wil be found 648 inches, and the whole solid content about 118500 inches.

As 1 vnto 21.6: so are 30 vnto 648:
As 1 vnto 648: so are 183 to 118584.

9 *Ha-*

9 ***Hauing the length, bredth and depth of a squared solid giuen in inches, to find the content in feet.***

As 1 to the bredth in inches:
So the depth in inches to the base in inches.

As 1728 to that base:
So the length in inches to the content in feet.

So in the solid *A H*, the content will be found to be about 68 feet 62 parts.

As 1 vnto 21.6: so 30 vnto 648:
As 1728 vnto 648: so 183 to 68.62.

Or as 12 to the bredth in inches:
So the depth in inches to a fourth number.
As 144 to that fourth number:
So the length in inches to the content in feet.

And so also in the same solid A H, the content will be found to be about 68 feet 62 parts.

As 12 vnto 21.6: so 30 vnto 54:
As 144 vnto 54: so 183 vnto 68.62.

10 ***Hauing the length, bredth and depth of a squared solid giuen in foot measure, to finde the content in feet.***

As 1 vnto the bredth in foot measure:
So the depth in feet to the base in feet.

As 1 vnto that base:
So the length in feet to the content in feet.

And thus in the former solid A H, the bredth *A C* will be 2 foot 50 parts, the depth *A E* 1 foot 80 parts, and the length *A B* 15 foot 25 parts; then working as before, the content of the base *A F* will be found 4 feet 50 parts, and the whole solid content about 68 foot 62 parts, which of all others may

very easily be tried by arithmetique.

As 1 vnto 2.50: so 1.80 vnto 4.50.

As 1 vnto 4.50: so 15.25 vnto 68.625.

11 *Hauing the bredth and depth of a squared solid giuen in inches, and the length in foot measure, to find the content thereof in feet.*

As 1 vnto the bredth in inches:
So the depth in inches vnto a fourth number: which is the content of the base in inches.

As 144 hath vnto that fourth number:
So the length in feet to the content in feet.

And so in the same solid A H, the content will be found to be about 68 feet 62 parts.

As 1 vnto 21.6: so 30 vnto 648.

As 144 vnto 15.25: so 648 vnto 68.62.

Or as 144 vnto the bredth in inches:
So the depth in inches vnto a fourth number: which is the content of the base in feet.

As 1 hath vnto that fourth number:
So the length in feet to the content in feet.

And so in the same solid AH, the content will be found to be about 68 feet 62 parts.

As 144 vnto 21.6: so 30 vnto 4.50:

As 1 vnto 4.50: so 15.25 vnto 68.62.

Or as 12 vnto the bredth in inches:
So the depth in inches vnto a fourth number.

As 12 vnto this fourth number:
So the length in feet to the content in feet.

And so also in the same solid AH, the content wil be found to be about 68 feet 62 parts.

As 12 vnto 21.6: so 30 vnto 54.

As 12 vnto 54: so 15.25 vnto 68.62.

All these varieties (and such like not here mentioned)
do

do follow vpon making of the base of the solid, to be EC; there would be as many more if any shall begin with the base E H, and so likewise if they make the base to be F D.

12 *Hauing the diameter of a cylinder giuen in inch measure, to find the length of a foot solid in inches.*

As the diameter in inches vnto 46.90:
So is 1 vnto a fourth number:
and that fourth to the length in inches.

So the diameter of a cylinder being 15 inches, the fourth number will be about 3.12, and the length of a foote solid 9 inches 78 parts.

As 15 vnto 46.90: so 1 vnto 3.127:
and so are 3.127 vnto 9.778.

13 *Hauing the diameter of a cylinder giuen in foot measure, to find the length of a foot solid in feet measure.*

As the diameter in feet vnto 1.128:
So is 1 vnto a fourth number;
and that fourth to the length in foot measure.

So the diameter being 1 foot 25 parts, the length of a foot solid will be found about 8.14 parts of 1000.

As 1.25 vnto 1.128: so 1.00 to 0.9027:
and so are 9027 vnto 8148.

14 *Hauing the circumference of a cylinder giuen in inches, to find the length of a foot solid in inch measure.*

As the circumference in inches to 147.36:
So is 1 to a fourth number;
and that fourth to the length in inches.

So the circumference being 47 inches 13 parts, the length of a foot solid will be found about 9 inches 78 parts.

As 47.13 vnto 147.36: so 1.00 to 3.13:
and so are 3.13 vnto 9.78.

15 *Hauing the circumference of a cylinder giuen in foot measure, to find the length of a foot solid in foot measure.*

As the circumference in feete to 3.545:
So is 1 to a fourth number;
and that fourth to the length in foot measure.

So the circumference being 3 foot 927 parts, the length of a foot solid will be found to be about 815 parts.

As 3.927 vnto 3.545: so 1.000 vnto 0.903:
and so are 903 vnto 815.

16 *Hauing the side of a square equall to the base of a cylinder, to find the length of a foot solid.*

The side of a square equall to the circle, may be found by the eighth *Prop.* of broad measure, and then this *Prop.* may be wrought by the first and second *Prop.* of solid measure.

17 *Hauing the diameter of a cylinder, and the length giuen in inches, to find the content in inches.*

As 1.128 vnto the diameter in inches:
So the length in inches to a fourth number;
and that fourth number to the content in inches.

So the diameter being 15 inches, and the length 105, the content of the cylinder will be found to be about 18560 inches.

As 1.1284 vnto 15: so are 105 vnto 1395.87:
and so are 1395.87 vnto 18555.34.

18 ***Hauing the diameter and length of a cylinder in foot measure, to find the content in feet.***

As 1.128 to the diameter in feet:
So the length in feet to a fourth number;
and that fourth to the content in feet.

So the diameter being 1 foote 25 parts, and the length 8 foot and 75 parts, the content of the cylinder will be found about 10 foot 74 parts.

As 1.128 vnto 1.25: so 8.75 vnto *9.69*:
and so are *9.69* vnto 10.737.

19 ***Hauing the diameter of a cylinder, and the length giuen in inches, to find the content in feet.***

As 46.90 to the diameter in inches:
So the length in inches to a fourth number;
and that fourth to the content in feet.

So the diameter being 15 inches, and the length 105, the content will be found about 10 foot 74 parts.

As 46.906 vnto 15: so 105 vnto 33.58:
and so are 33.58 vnto 10.737.

20 ***Hauing the diameter of a cylinder giuen in inches and the length in feet, to find the content in feet.***

As 13.54 to the diameter in inches:
So the length in feet to a fourth number;
and that fourth to the content in feete.

So the diameter being 15 inches, and the length 8 foote 75 parts, the content will be found about 10 foot 74 parts.

As 13.54 vnto 15: so 8 75 vnto *9.69*:
and so are *9.69* vnto 10.74.

21 *Hauing the circumference and the length of a cylinder giuen in inches, to find the content in inches.*

As 3.545 to the circumference in inches:
So the length in inches to a fourth number;
and that fourth to the content in inches.

So the circumference being 47 inches 13 parts, and the length 105 inches, the content will be found about 18560 inches.

As 3.545 vnto 47.13: so 105 vnto 1396:
and so are 1396 vnto 18555.

22 *Hauing the circumference and length of a cylinder giuen in inches, to find the content in feet.*

As 147.36 to the circumference in inches:
So the length in inches to a fourth number;
and that fourth to the content in feet.

So the circumference being 47 inches 13 parts, and the length 105 inches, the content will be found about 10 foote 74 parts.

As 147.36 vnto 47.13: so 105 vnto 33.58:
and so are 33.58 vnto 10.74.

23 *Hauing the circumference and length of a cylinder giuen in foot measure, to find the content in feet.*

As 3.545 to the circumference in feet:
So the length in feet to a fourth number;
and that fourth to the content in feet.

So the circumference being 3 foote 927 parts, and the length 8 foot 75 parts, the content wil be found to be 10 foote 74 parts.

As 3.545 vnto 3.927: so 8.75 vnto 9.69:
and so are 9.69 vnto 10.74.

24 ***Hauing the circumference of a cylinder giuen in inches, and the length in foot measure, to find the content in feete.***

As 42.54 to the circumference in inches:
So the length in feet to a fourth number;
and that fourth to the content in feet.

So the circumference being 47 inches 13 parts, and the length 8 foot 75 parts, the content will be found as before, 10 foot 74 parts.

As 42.54 vnto 47.13: so 8.75 vnto *9.69*:
and so are *9.69* vnto 10.74.

CHAP. IIII.

The vse of the line of Numbers in gaugeing of vessels.

THe vessels which are here measured, are supposed to be cylinders, or reduced vnto cylinders, by taking the mean betweene the diameter at the head and the diameter at the bongue, after the vsuall maner.

1 ***Hauing the diameter and the length of a vessell with the content thereof, to find the gauge point.***

Extend the compasses in the line of ***numbers*** to halfe the distance betweene the content and the length of the vessell, the same extent will reach from the diameter to the gauge point.

I put this proposition first, because these kind of measures are not alike in all places. Here at London it is said that a wine vessell being *66* inches in length, and 38 inches the diameter, would containe 324 gallons: which if it be true, we

may diuide the space betweene 324 and 66 into two equall parts, and the middle will fall about 146, and the same extent which reacheth from 324 to 146, wil reach from the diameter 38 vnto 17.15 the gauge point for a gallon of wine or oyle after London measure. The like reason holdeth for the like measures in all other places.

2 *Hauing the meane diameter and the length of a vessell, to find the content.*

Extend the compasses from the gauge point to the meane diameter, the same extent being doubled, shall giue the distance from the length to the content.

So the meane diameter of a wine vessell being 20 inches, and the length 25 inches, the content will be found to be 34 gallons after Londō measure. For extend the compasses from 17.25 vnto 20, the same extent wil reach from 25 vnto 29.15, and from 29.15 vnto 34.

In like maner if the meane diameter were 16 inches, and the length 23, the content would be found to be about 20 gallons. For the same extent which reacheth back from 17.15 vnto 16, will reach from 23 to 21.45, and from 21.45 vnto 20.

So that if the meane diameter shall be 17 inches and 15 centesmes or parts of 100, the number of inches in the length of the vessell, will giue the number of gallons contained in the same vessell: if the diameter shall be more or lesse then 17.15, the content in gallons will be accordingly more or lesse then the length in inches.

3 *Hauing the diameter and content, to find the length.*

Extend the compasses from the diameter to the gauge point, the same extent being doubled shall giue the distance from the content to the length of the vessell.

So the gauge point standing as before, if the diameter shal be 38 inches, and the content 324 gallons wine measure, the length

length of the vessels will be found about 66 inches.

4 ***Hauing the length of a vessell and the content, to find the diameter.***

Extend the compasses to halfe the distance betweene the length and the content, the same extent shall reach from the gauge point to the diameter.

So the length being 66 inches, and the content 324 gallons wine measure, the gauge point standing as before, the diameter of the vessell will be found to be about 38 inches.

CHAP. V.

Containing such Astronomicall propositions as are of ordinary vse in the practise of Nauigation.

1 ***To find the altitude of the Sunne by the shadow of a gnomon set perpendicular to the horizon.***

As the parts of the shadow
are to the parts of the gnomon:
So the tangent of 45 *gr.*
to the tangent of the altitude.

Extend the compasses in the line of *numbers*, from the parts of the shadow to the parts of the *gnomon*; the same extent will giue the distance from the tangent of 45 *gr.* to the tangent of the Sunnes altitude.

So the *gnomon* being 36, and the shadow 27, the altitude will be found to be 36 *gr.* 32 *m.* Or the *gnomon* being 27, and the shadow 36, the altitude will be found to be 53 *gr.* 8 *m.* Or the shadow being 20, and the gnomon 9, the altitude will be found to be 25 *gr.* 14 *m.* as in the eighth *Prop.* of the vse of the *tangent* line.

2 *Hauing the distance of the Sunne, from the next equinoctiall point, to find his declination.*

As the Radius is in proportion
to the sine of the Sunnes greatest declination:
So the sine of the Suns distance from the next equinoctiall point,
to the sine of the declination required.

Extend the compasses in the line of *sines*, from **90 *gr.*** to 23 *gr.* 30 ***m.*** the same extent will giue the distance from the Sunnes place vnto his declination.

So the Sunne being either in 29 *gr.* of ♉, or **1** *gr.* of ♒, or 1 *gr.* of ♌, or 29 *gr.* of ♏, that is 59 *gr.* distant from the next equinoctiall point, the declination will be found about 20 *gr.*

If the Sunne be so neare the equinoctiall point that his declination fall to be vnder 1 *gr.* it may be found by the line of *numbers*. As if the Sunne were in 2 *gr.* 5 *m.* of ♈, that is, 125 *m.* from the equinoctiall point, the former extent of the compasses from the sine of 90 *gr.* to the sine of 23 *gr.* 30 *m.* will reach in the line of *numbers* from 125 vnto 50, which shewes the declination to be about 50 *m.*

3 *Hauing the latitude of the place, and the declination of the Sun, to find the time of the Suns rising and setting.*

As the cotangent of the latitude
to the tangent of the *Suns* declination:
So is the Radius
to the sine of the ascensionall difference betweene the houre of 6 and the time of the *Suns* rising or setting.

Extend the compasses from the tangent of the complement of the latitude, to the tangent of the declination: the same extent wil reach from the sine of 90 *gr.* to the sine of the ascensionall difference.

Or extend the compasses from the cotangent of the latitude

to the sine of 90 *gr*, the same extent will reach from the tangent of the declination to the sine of the ascensionall difference.

So the latitude being 51 *gr*. 30 *m*. Northward, and the declination 20 *gr*. the difference of ascension wil be found to be 27 *gr*. 14 *m*. which resolued into houres and minutes, doth giue 1 houre and almost 49 *m*. for the difference betweene the Sunnes rising or setting, and the houre of 6, according to the time of the yeare.

4 *Hauing the latitude of the place, and the distance of the Sun from the next equinoctiall point, to find his amplitude.*

As the cosine of the latitude
to the sine of the Suns greatest declination:
So the sine of the place of the Sun,
to the sine of the amplitude.

So the latitude being 51 *gr*. 30 *m*. and the place of the Sun in 1 *gr*. of ♒, that is 59 *gr*. distant from the next equinoctiall point, the amplitude will be found about 33 *gr*. 20 *m*. For extend the compasses in the line of *sines*, from 38 *gr*. 30 *m*. the sine of the complement of the latitude, vnto 23 *gr*. 30 *m*. the sine of the Suns greatest declination; the same extent will reach from 59 *gr*. vnto 33 *gr*. 20 *m*. Or extend them from 38 *gr*. 30 *m*. vnto 59 *gr*. the same extent will reach from 23 *gr*. 30 *m*. vnto 33 *gr*. 20 *m*. as before.

5 *Hauing the latitude of the place, and the declination of the Sun, to find his amplitude.*

As the cosine of the latitude
is to the Radius:
So the sine of the declination,
to the sine of the amplitude.

Extend the compasses from the cosine of the latitude to the

the sine of 90 *gr.* the same extent will reach from the sine of the Suns declination to the sine of the amplitude.

Or extend them from the cosine of the latitude to the sine of the declination, the same extent will reach from the sine of 90 *gr.* to the sine of the amplitude.

So the latitude being 51 *gr.* 30 *m.* and the declination 20 *gr.* the amplitude will be found to be 33 *gr.* 20 *m.*

6. *Hauing the latitude of the place, and the declination of the Sun, to find the time when the Sun cometh to be due East or West.*

As the tangent of the latitude,
is to the tangent of the declination.
So the Radius
to the cosine of the houre from the meridian.

Extend the compasses from the tangent of the latitude to the tangent of the declination; the same extent will reach from the sine of 90 *gr.* to the sine of the complement of the houre.

Or extend them from the tangent of the latitude to the sine of 90 *gr*; the same extent will reach from the tangent of the declination to the sine of the complement of the houre.

So the latitude being 51 *gr.* 30 *m.* and the declination 20 *gr.* the Sunne will be 73 *gr.* 10 *m*: that is 4 houres and 53 *m.* fro the meridian, when he cometh to be in the East or West.

7. *Hauing the latitude of the place, and the declination of the Sun, to find what altitude the Sun shall haue, when he cometh to be due East or west.*

As the sine of the latitude
is to the sine of the declination:
So the Radius
to the sine of the altitude.

Extend the compasses in the line of *lines* from the latitude

to the sine of the declination, the same extent will reach from the sine of *90 gr.* to the sine of the altitude.

Or extend them from the sine of the latitude to the sine of *90 gr*; the same extent will reach from the sine of the declination to the sine of the altitude.

So the latitude being 51 *gr.* 30 *m.* and the declination 20 *gr.* the altitude will be found about 25 *gr.* 55 *m.*

8 *Hauing the latitude of the place, and the declination of the Sun, to find what altitude the Sun shall haue at the houre of six.*

As the Radius is in proportion
 to the sine of the sine of the declination:
So the sine of the latitude
 to the sine of the altitude.

Extend the compasses in the line of *sines*, from 90 *gr.* to the declination; the same extent will reach from the latitude to the altitude.

Or extend them from 90 *gr.* to the latitude, the same extent will hold from the declination to the altitude.

So the latitude being 51 *gr.* 30 *m.* and the declination of the Sunne 20 *gr.* the altitude of the Sun will be found to be about 15 *gr.* 30 *m.*

9 *Hauing the latitude of the place, and the declination of the Sun, to find what azimuth the Sun shall haue at the houre of six.*

As the cosine of the latitude
 is to the Radius:
So the cotangent of the Suns declination,
 to the tangent of the azimuth from the North part of the meridian.

So

So the latitude being 51 *gr.* 30 *m.* and the declination 20 *gr.* the azimuth will be found to be 77 *gr.* 14 *m.* For extend the compasses in the line of *sines*, from 38 *gr.* 30 *m.* to 90 *gr.* the same extent will reach from the tangent of 70 *gr.* to the tangent of 77 *gr.* 14 *m.*

10 *Hauing the latitude of the place, and the declination of the Sun, and the altitude of the Sun, to find the azimuth.*

First consider the declination of the Sunne, whether it be toward the North or the South, so haue you his distance from your pole: then adde this distance, the complement of his altitude, and the complement of your latitude, all three together, and from halfe the summe subtract the distance from the pole, and note the difference.

1 As the Radius is in proportion
to the cosine of the altitude:
So the cosine of the latitude,
to a fourth sine.

2 As this fourth sine
is to the sine of the halfe summe:
So the sine of the difference,
to a seuenth sine.

Then find a meane proportionall betweene this seuenth sine and the Radius, this meane shall be the sine of the complement of halfe the azimuth from the North part of the meridian.

Suppose the declination of the Sun being knowne by the time of the yeare to be 20 *gr.* Southward, the altitude aboue the horizon found by obseruation 12 *gr.* and the latitude Northwards 51 *gr.* 30 *m.* it were required to find the azimuth. The declination is Southward, and therefore the distance from the pole 110 *gr*; then turning the altitude and latitude vnto their complements, I adde them all three together, and from halfe the summe subtract the distance from the pole, noting

noting the difference after this maner.

Declin. South	20 *gr.*	0 *m.*	The distance	110 *gr.*	0 *m.*
Altitude	12	0	The complement	78	0
Latitude N.	51	30	The complement	38	30
			The summe of all three	226	30
			The halfe summe	113	15
			The difference	3	15

This done, I come to the Staffe, and extend the compasses from the sine of 90 *gr.* to the sine of 78 *gr.* and find the same extent to reach from the sine of 38 *gr.* 30 *m.* vnto 37 *gr.* 30 *m.* Or if I extend them from 90 *gr.* to 38 *gr.* 30 *m.* the same extent doth reach from 78 *gr.* vnto 37 *gr.* 30 *m.* which is the fourth sine required.

Then I extend the compasses againe, from this fourth sine of 37 *gr.* 30 *m.* vnto the sine of the halfe summe 113 *gr.* 15 *m.* that is to the sine of 66 *gr.* 45 *m.* (for after 90 *gr.* the sine of 80 *gr.* doth stand for a sine of 100 *gr.* and the sine of 70 *gr.* for a sine of 110 *gr.* and so the rest for those which are their complements to 180 *gr.*) and this second extent doth reach from the sine of the difference 3 *gr.* 15 *m.* to the sine of 4 *gr.* 54 *m.* Or if I extend them from the fourth sine of 37 *gr.* 30 *m.* to the sine of the difference 3 *gr.* 15 *m.* the same extent will reach from the sine of the halfe summe 113 *gr.* 15 *m.* vnto 4 *gr.* 54 *m.* which is the seuenth sine required.

Lastly, I diuide the space betweene this seuenth sine of 4 *gr.* 54 *m.* and the sine of 90 *gr.* into two equall parts, and I find the meane proportionall sine to fall on 17 *gr.* whose complement is 73 *gr.*; the double of 73 *gr.* is 146 *gr.* and such is the azimuth required.

Or hauing found the seuenth sine to be 4 *gr.* 54 *m.* I might looke ouer against it, in the line of *versed sines*, and there I should find 146 *gr.* for the azimuth from the North part of the meridian; and the complement of 146 *gr.* to a semicircle being 34 *gr.* will giue the azimuth from the South part of the meridian.

But if it were required to find the azimuth in the same latitude of 51 *gr.* 30 *m.* Northward, with the same altitude of

12 *gr.* and like declination of 20 *gr.* to the Northward, it would be found to be onely 72 *gr.* 52 *m.* though the maner of worke be the same as before.

Declin. North	20 *gr.*	0 *m*	The distance is	70 *gr.*	0 *m.*
Altitude	12	0	The complement	78	0
Latitud. North	51	30	The complement	38	30
			The summe of all three	186	30
			The halfe summe	93	15
			The difference	23	15

Here as the Radius is to the sine of 78 *gr*: so the sine of 38 *gr.* 30 *m.* to the sine of 37 *gr.* 30 *m.* which is the fourth sine, and the same as before.

Then as this fourth sine of 37 *gr.* 30 *m.* is to the sine of 93 *gr.* 15 *m*: so the sine of 23 *gr.* 15 *m.* to the sine of 40 *gr.* 20 *m.* which is the seuenth sine.

The halfe way betweene this seuenth sine and the sine of 90 *gr.* doth fall at 53 *gr.* 34 *m.* whose complement is 36 *gr.* 26 *m*; and the double of that is 72 *gr.* 52 *m.* the azimuth required.

Or I may find this same azimuth in the line of *versed sines*, ouer against the seuenth sine of 40 *gr.* 20 *m.*

Hauing the latitude of the place, the declination of the Sun, and the altitude of the Sun, to find the houre of the day.

Adde the complement of the Suns altitude, and the distance of the Sun from the pole, and the complement of your latitude, all three together, and from halfe the summe subtract the complement of the altitude, and note the difference.

1 As the Radius is in proportion
to the sine of the Suns distance from the pole:
So the sine of the complement of the latitude,
to a fourth sine.

2 As this fourth sine
is to the sine of the halfe summe:
So the sine of the difference
to a seuenth sine.

The meane proportionall betweene this seuenth sine and the sine of 90 *gr.* will be the sine of the complement of halfe the houre from the meridian.

Thus in our latitude of 51 *gr.* 30 *m.* the declination of the Sun being 20 *gr.* Northward, and the altitude 12 *gr.* I might find the Sun to be 95 *gr.* 52 *m.* from the meridian.

Altitude	12 *gr.*	0 *m.*	The complement is	78 *gr.*	0 *m.*
Declin. North	20	0	the dist. from the pole	70	0
Latitude	51	30	the complement is	38	30
			The summe of all three	186	30
			The halfe summe	93	15
			The difference	15	15

Here as the Radius is to the sine of 70 *gr.*
So the sine of 38 *gr.* 30 *m.* to the sine of 35 *gr.* 48 *m.*

As this sine of 35 *gr.* 48 *m.* is to the sine of 93 *gr.* 15 *m.*
So the sine of 15 *gr.* 15 *m.* to the sine of 26 *gr.* 40 *m.*

The halfe may between this seuenth sine of 26 *gr.* 40 *m.* and the sine of 90 *gr.* doth fall at 42 *gr.* 4 *m.* whose complement is 47 *gr.* 56 *m.* and the double of that, 95 *gr.* 52 *m.* which conuerted into houres, doth giue 6 houres and almost 24 *m.* from the meridian.

Or I might find these 95 *gr* 52 *m.* in the line of *versed sines*, ouer against the seuenth sine of 26 *gr.* 40 *m.*

12 *Hauing the azimuth, the Suns altitude, and the declination, to find the houre of the day.*

As the cosine of the declination
is to the sine of the azimuth:
So the cosine of the altitude
to the sine of the houre.

h 2 Thus

Thus the declination being **20** *gr.* Southward, the altitude **12** *gr.* and the azimuth found by the tenth *Prop.* **146** *gr.* I might find the time to be **35** *gr.* **36** *m.* that is **2** houres **22** *m.* from the meridian.

13 *Hauing the houre of the day, the Sunnes altitude, and the declination, to find the azimuth.*

As the cosine of the altitude
is to the sine of the houre:
So the cosine of the declination,
to the sine of the azimuth.

So the altitude of the Sun being **12** *gr.* and the declination **20** *gr.* Southward, and the angle of the houre **35** *gr.* **36** *m.* I should find the azimuth to be **34** *gr.* And so it is if it be reckoned from the South; but **146** *gr.* if it be taken from the North part of the meridian.

14 *Hauing the distance of the Sun from the next equinoctiall point, to find his right ascension.*

As the Radius
to the cosine of the greatest declination:
So the tangent of the distance,
to the tangent of the right ascension.

So the Sun being in the first degree of ♒, that is **59** *gr.* distant from the next equinoctiall point, and the greatest declination **23** *gr.* **30** *m.* the right ascension will be found to be **56** *gr.* **46** *m.* short of the beginning of ♈, and therefore **303** *gr.* **14** *m.*

15 *Hauing the declination of the Sun; to find his right ascension.*

As the tangent of the greatest declination
is to the tangent of the declination giuen:

So the Radius
to the ſine of the right aſcenſion.

So the greateſt declination being 23 *gr.* 30 *m.* and the declination of the Sun giuen 20 *gr.* the right aſcenſion will be found about 56 *gr.* 50 *m.*

These are ſuch Aſtronomicall propoſitions as I take to be vſefull for Sea-men. For the firſt and ſecond will help them to find their latitude; the third to find the Suns riſing and ſetting; the 4.5.6.7.8.9.10.13. *Prop.* to finde the variation of their compaſſe; the 11 and 12 *Prop.* to find the houre of the day; and the two laſt toward the finding of the houre of the night. For hauing the latitude of the place, with the declination and altitude of any ſtarre, they may find the houre of the ſtarre from the meridian, as in the 11 *Prop.* Then comparing the right aſcenſion of the ſtarre with the right aſcenſion of the Sunne, they may haue the houre of the night.

All theſe propoſitions and ſuch others may be wrought alſo by the tables of *ſines* and *tangents.* For where foure numbers do hold in proportion; as the firſt to the ſecond, ſo the third to the fourth; there if we multiply the ſecond into the third, and diuide the product by the firſt, the quotient will giue the fourth required. As in the example of the laſt *Prop.* where the delination being giuen, it was required to find the right aſcenſion. The tangent of 20 *gr.* the declination giuen is 3639702, which being multiplied by the Radius, the product is 36397020000000, and this diuided by 4348124 the tangent of 23 *gr.* 30 *m.* the quotient is 8370741 the ſine of 56 *gr.* 50 *m.* for the right aſcenſion required.

Or if any will vſe my tables of *artificiall ſines* and *tangents*, they may adde the ſecond and the third together, and from the ſumme ſubtract the firſt, the remainder will giue the fourth required. And ſo my tangent of 20 *gr.* is 9561.0658, which being added to the Radius, makes 19561.0658; from this if they ſubtract 9638.3019 the tangent of 23 *gr.* 30 *m.* they ſhall find the remainder to be 9922.7639, which in my

Canon is the sine of 56 *gr.* 49 *m.* 56 *secōds*; and such is the right ascension required, if it be reckoned from the next equinoctiall point.

The like reason holdeth for all other Astronomicall propositions, as I will farther shew by those two examples which I gaue before for the finding of the azimuth in the 10 *Prop.* because they are thought to be harder then the rest, and require three operations.

In the first example.

Declin. South	20 *gr.*	0 *m.*	The distance	110 *gr.*	0 *m.*
Altitude	12	0	the complement	78	0
Latitude Nor	51	30	the complement	38	30
			The summe of all three	226	30
			The halfe summe	113	15
			The difference	3	15

The first operation will be to finde the fourth sine; and that is done by adding the sine of the complement of the altitude to the sine of the complement of the latitude, and subtracting the Radius: so adding 9990.4044 the sine of 78 *gr.* vnto 9794.1495 the sine of 38 *gr.* 30 *m.* the summe wll be 19784.5539. And the Radius being subtracted, the remainder 9784.5539 is the fourth sine, and belongeth to 37 *gr.* 30 *m.*

The second operation will be to find the seuenth sine; and that is done by adding the sine of the halfe summe to the sine of the difference, and subtracting the fourth sine. So the halfe summe being 113 *gr.* 15 *m.* I take his complement to a semicircle, and so find his sine to be 9963.2168, to which I adde 8753.5278, the sine of the difference 3 *gr.* 15 *m.*; and the summe is 18716.7446. From this I take the fourth sine 9784.5539, and the remainder will be 8932.1907, which is the seuenth sine, and belongeth to 4 *gr.* 54 *m.*

The third operation will be to finde the meane proportionall sine betweene the seuenth sine and the Radius. This in common arithmetique is done by multiplying the two extremes, and taking the square roote of the product. As in

finding

finding a meane proportionall betweene 4 and 9, we multiply 4 into 9, and the product is 36, whose square root is 6, the meane proportionall between 4 and 9. But here it is done by adding the sine and the Radius, and taking the halfe of them. So the summe of the last seuenth sine and the Radius is 18932.1907 and the halfe of that 9466.0953, which is the meane proportionall sine required, and belongeth to 17 *gr.* whose complement is 73 *gr.* and the double of that 146 *gr.* the same azimuth as before.

In the second example.

Declin. North	20 *gr.*	0 *m.*	The distance	70 *gr.*	0 *m.*
Altitude	12	0	the complement	78	0
Latitud. North	51	30	the complement	38	30
	The summe of all three			186	30
	The halfe summe			93	15
	The difference			23	15

The first operation will be to finde the fourth sine; and that is here 9784.5539, as in the former example.

The second operation wil be to find the seuenth sine; and where the sine of the halfe summe 93 *gr.* 15 *m.* being the same with the sine of 86 *gr.* 45 *m.* his complement to 180 *gr.* I find it to be 9999.3009, to which I adde 9596.3153 the sine of the difference 23 *gr.* 15 *m.* and the summe is 19595.6162. From this I take the fourth sine 9784.5539, and the remainder will be 9811.0623 for the seuenth sine, and belongeth to 40 *gr.* 20 *m.*

The third operation will be to find the meane proportionall sine betweene the seuenth sine and the Radius. And so here the Radius being added to the seuenth sine, the summe will be 19811.0623, and the halfe of that 9905.5311 doth giue the meane proportionall sine belonging to about 53 *gr.* 34 *m.* whose complement is 36 *gr.* 26 *m.* & the double of that 72 *gr.* 52 *m.* the same azimuth as before.

I haue set downe these three examples thus particularly, that I might shew the agreement between the *Staffe* and the *Canon*. But otherwise I might deliuer both the precept and the

the worke, for the two last, more compendiously. For generally in all sphericall triangles, where three sides are knowne, and an angle required, make that side which is opposite to the angle required, to be the base; and gather the summe, the halfe summe, and the difference as before,

As the rectangle contained vnder the sines of the sides,
is to the square of the whole sine:
So the rectangle contained vnder the sines of the halfe
summe and the difference,
to the square of the cosine of halfe the angle.

Then for the worke, we may for the most part leaue out the two last figures; and if they be aboue 50, put an vnitie to the sixt place, after this maner.

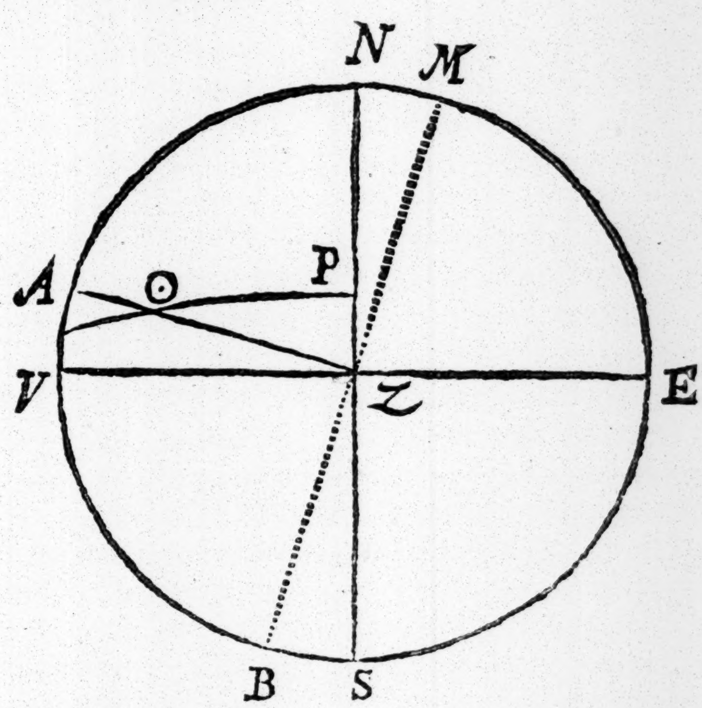
The second example.

70 gr. 0 m.			
78	0	9990 40	
38	30	9794 15	
186	30	19784|55	
93	15	9999 30	
23	15	9596 32	
		20000 00	
		39595 62	
		19811 07	
36	26	9905 53	53 gr. 34 m.
72	52		107 8

Or for such numbers as are to be subtracted, I may take them out of the Radius, and write downe the residue, and then adde them together with the rest. As in the same second example, the sines of 78 *gr.* and of 38 *gr.* 30 *m.* being the numbers to be subtracted; if I take 9990.4044 the sine of 78 *gr.* out of the Radius 10000 0000, the residue is 9.5956: and so the residue of 9794.1495 is 205.8505. Wherefore in stead of subtracting those sines, I may adde these residues after this maner:

70 *gr.* 0 *m.*				
78	0	9 59		
38	30	205 85		
186	30			
93	15	9999 30		
23	15	9596 32		
		19811 06		
36	26	9905 53	53 *gr.* 34 *m.*	
72	52		107	8

Hauing these meanes to find the Sunnes azimuth, we may compare it with the magneticall azimuth, and so finde the variation of the needle.



For let the circle *A M B*, drawne on the center *Z*, be a plane, parallell to the horizon; *A* the point whereon the Sun beareth from vs, *M* the North point of the magneticall needle, and the angle *A Z M* the magneticall azimuth. If we find the Sunnes azimuth as before, to be 7 2 *gr.* 5 2 *m.* from the North to the Westward, we may allow so many degrees from *A* vnto *N*, and so we haue the true North point from the meridian, and consequently the East, South, and West points of the horizon; and the distance betweene *N* and *M* shall be

the variation of the needle. So that if the magneticall azimuth *AZM* shall be 84 *gr*. 7 *m*. and the Suns azimuth *AZN* 72 *gr*. 52 *m*. then must *NZM* the difference betweene the two meridians, giue the variation to be 11 *gr*. 15 *m*. as Mr. *Bourough* heretofore found it by his obseruations at *Limehouse* in the yeare 1580. But if the magneticall azimuth *AZM* shall be 79 *gr*. 7 *m*. and the Suns azimuth *AZN* 72 *gr*. 52 *m*. then shall the variation *NZM* be only 6 *gr*. 15 *m*. as I haue sometimes found it of late. Herevpon I enquired after the place where Mr. *Bourough* obserued, and went to *Limehouse* with some of my friends, and tooke with vs a quadrant of 3 foote semidiameter, and two needles, the one aboue 6 inches, and the other 10 inches long, where I made the semidiameter of my horizontall plane *AZ* 12 inches: and toward night the 13 of Iune 1622, I made obseruation in seuerall parts of the ground, and found as followeth.

Alt. ☉		*AZM*		*AZN*		*Variat*	
Gr.	*M.*	*Gr.*	*M.*	*Gr.*	*M.*	*Gr.*	*M.*
19	0	82	2	75	52	6	10
18	5	80	50	74	44	6	6
17	34	80	0	74	6	5	54
17	0	79	15	73	20	5	55
16	18	78	12	72	32	5	40
16	0	77	50	72	10	5	40
20	10	71	2	64	49	6	13
9	52	70	12	64	25	5	47

CHAP.

CHAP. VI.

Containing ſuch nauticall queſtions, as are of ordinary vſe, concerning longitude, latitude, Rumb, and diſtance.

1 *To keep an account of the ſhips way.*

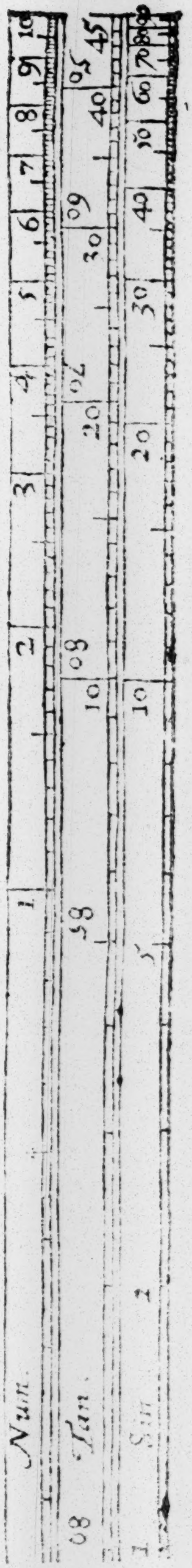
THe way that the ſhip maketh, may be knowne to an old ſea-man by experience, by others it may be found for ſome ſmall portion of time, either by the log line, or by the diſtance of two knowne markes on the ſhips ſide. The time in which it maketh this way, may be meaſured by a watch, or by a glaſſe. Then as long as the wind continueth at the ſame ſtay, it followeth by proportion,

As the time giuen is to an houre:
So the way made, to an houres way.

Suppoſe the time to be 15 ſeconds, which make a quarter of a minute, and the way of the ſhip 88 feet: then becauſe there are 3600 ſeconds in an houre, I may extend the compaſſes in the line of ***numbers***, from 15 vnto 3600, and the ſame extent will reach from 88 vnto 21120.

Or I may extend them from 15 vnto 88, and this extent will reach from 3600 vnto 21120; which ſhewes that an houres way came to 21120 feete.

But this were an vnneceſſary buſineſſe, to hearken after feet or fadoms. It ſufficeth our ſea-men to find the way of their ſhip in leagues or miles. And they ſay that there are 5 feet in a pace, 1000 paces in a mile, and 60 miles in a degree, and therefore 300000 feete in a degree. Yet compa-



ring seuerall obseruations, and their measures with our feete vsuall about *London*, I find that we may allow 352000 feete to a degree; and then if I extend the compasses in the line of *numbers* from 352000 vnto 21120, I shall find the same extent to reach from 20 leagues the measure of one degree, to 1.2, and from 60 miles to 3.6; which shewes the houres way to be a league and 2 tenths of a league, or 3 miles and 6 tenths of a mile.

But to auoid these fractions and other tedious reductions, I suppose it would be more easie to keep this account of the ships way (as also of the difference of latitude, and the difference of longitude) by degrees and parts of degrees, allowing 100 parts to each degree, which we may therefore call by the name of *centesmes*. Neither would this be hard to conceiue. For if 100 such parts do make a degree, then shall 50 parts be equall to 30 minutes, as 30 minutes are equall to 10 leagues. And 5 parts shall be equall to 3 minutes, as 3 minutes are equall to 1 league. And so the same extent as before, will reach from 100 parts vnto 6; which shewes that the houres way required is 6 *cent.* such as 100 do make a degree, and 5 do make an ordinary league.

This might also be done at one operation. For vpon these suppositions, diuide 44 feet into 45 lengths, and set as many of them as you may conueniently betweene two markes on the ships side, and note the seconds of time in which the ship goeth these lengths: so the lengths diuided by the time, shall giue the *cent.* which the ship goeth in an houre.

Suppose the distance betweene the two markes to be 60 lengths (which are 58 feet and 8 inches) and let the time be 12 seconds: extend the compasses from 12 to 1, in the line of *numbers*; so the same extent will reach from 60 vnto 5. Or extend them from 12 vnto 60, and the same extent will reach from 1 vnto 5. This shewes that the ships way is according to 5 *cent.* in an houre.

This may be found yet more easily, if the log line shall be fitted to the time. As if the time be 45 seconds, the log line may haue a knot at the end of euery 44 feete; then doth the

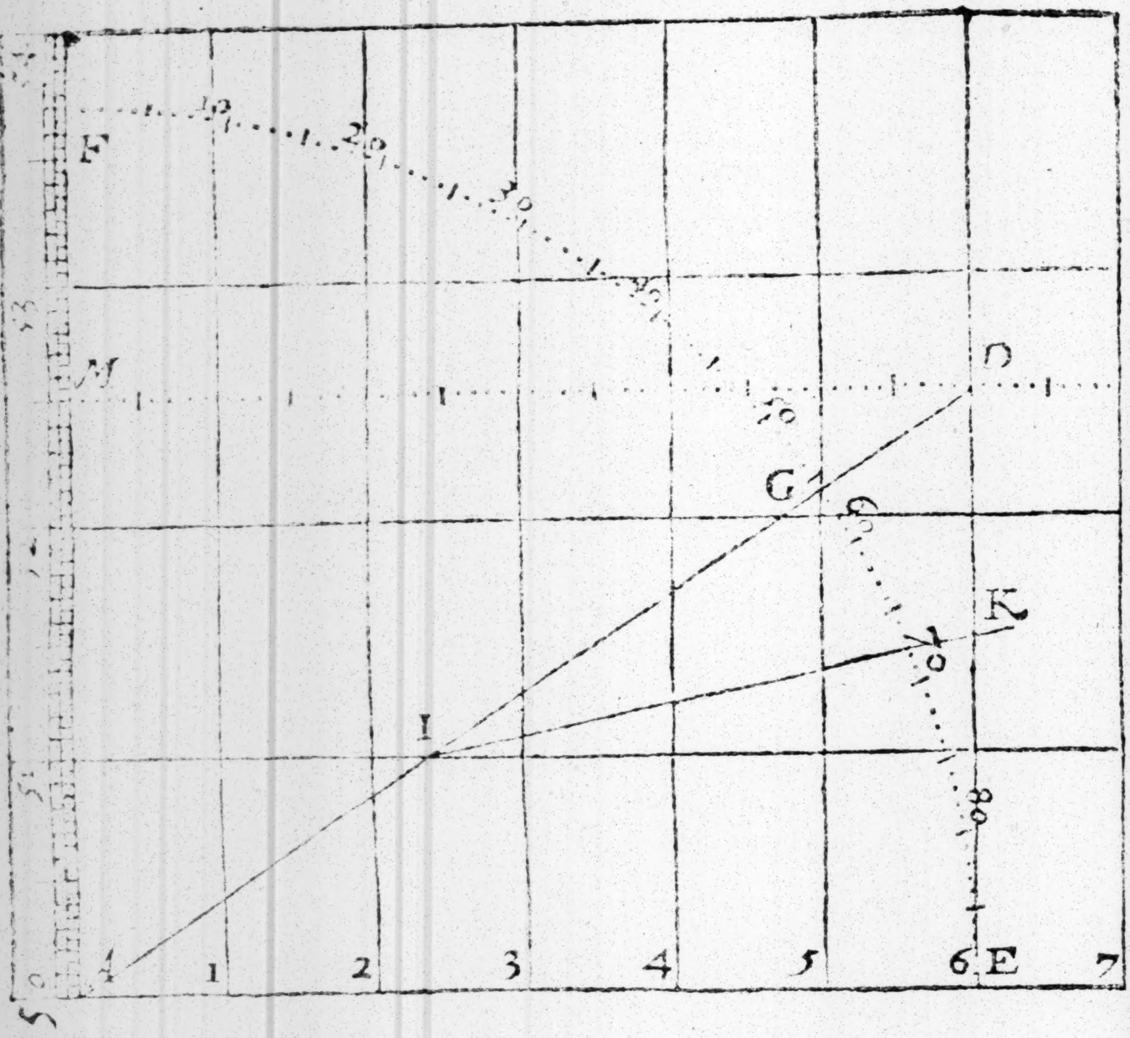
ship

ship run so many *cent.* in an houre, as there are knots vered out in the space of 45 seconds. If 30 seconds do seeme to be a more conuenient time, the log line may haue a knot at the end of euery 29 feet and 4 inches; and then also the *centesmes* will be as many as the knots. Or if the knots be made to any set number of feet, the time may be fitted vnto the distance. As if the knots be made at the end of euery 24 feet, the glasse may be made 24 seconds and somewhat more then an halfe of a second; and so these knots will shew the *cent.* If there be 5 knots vered out in a glasse, then 5 *cent*; if 6 knots, then the ship goeth 6 *cent.* in the space of an houre; and so in the rest. For vpon this supposition, the proportion between the time and the feet will be as 45 vnto 44. But according to the common supposition it should seeme to be as 45 vnto 37 $\frac{1}{2}$, or in lesser termes as 6 vnto 5. Those which are vpon the place, may make proofe of both, and follow that which agrees best with their experience.

2 *By the latitude and difference of longitude, to find the distance vpon a course of East and West.*

Extend the compasses from the sine of 90 *gr.* vnto the sine of the complement of the latitude; the same extent shal reach in the line of *numbers* from the difference of longitude to the distance.

So the measure of one degree in the equator, being 100 *cent.* the distance belonging to one degree of longitude in the latitude of 51 *gr.* 30 *m.* will be found about 62 *cent.* and $\frac{1}{4}$. Or if the measure of a degree be 60 miles, the distance will be found about 37 miles and $\frac{1}{3}$. If the measure be 20 leagues, then almost 12 leagues and $\frac{1}{2}$. If the measure be 17 $\frac{1}{2}$, as in the Spanish charts, then somewhat lesse then 11 leagues sailing vpon this parallell, will giue an alteration of one degree of longitude.



3 By the latitude and distance vpon a course of East or west, to find the difference of longitude.

Extend the compasses from the sine of the complement of the latitude, to the sine of 90 *gr*; the same extent wil reach in the line of *numbers* from the distance to the difference of longitude.

So the distance vpon a course of East or West, in the latitude of 51 *gr*. 30 *m*. being 100 *cent*. the difference of longitude will be found 1.60, which make one degree and 60 *centesmes* or 1 *gr*. 36 *m*.

Or if it be 60 miles, the difference of longitude wil be 96, which also make 1 *gr*. 36 *m*. as before.

4 The

4 *The longitude and latitude of two places being giuen, to find the Rumb leading from the one to the other.*

Extend the compasses in the line of *numbers* from the difference of latitudes to the difference of longitudes; the same extent will giue the distance from the tangent of 45 *gr.* vnto the tangent of the Rumb, according to the proiection of the common sea-chart.

So the latitude of the first place being 50 *gr.* the latitude of the second 52 *gr.* 30 *m.* and the difference of longitude 6 *gr.* the Rumb will be found to be about 67 *gr.* 23 *m.* which is neare the inclination of the sixth Rumb to the meridian. But this Rumb so found, is alwayes greater then it should be, and therefore to be limited; which may be done sufficiently for the Sea-mans vse, after this maner:

Extend the compasses either from the sine of 90 *gr.* vnto the sine of the complement of the middle latitude, the same extent will reach frō the tangent of the Rumb before found, to the tangent of the Rumb limited.

Or else extend them from the sine of 90 *gr.* vnto the tangent of the Rumb before found; the same extent will reach from the sine of the complement of the middle latitude, vnto the tangent of the Rumb limited.

So the middle latitude between 50 *gr.* and 52 *gr.* 30 *m.* being 51 *gr.* 15 *m.* and the Rumb before found 67 *gr.* 23 *m.* the Rumb limited will be found to be about 56 *gr.* 20 *m.* which is but fiue minutes more then the inclination of the fift Rumb to the meridian.

2 This Rumb may be found by the helpe of the *meridian line* vpon the Staffe. For if I take the difference of latitude out of the *meridian line* from 50 *gr.* vnto 52 *gr.* 30 *m.* and measure it in his equinoctiall, or at the beginning of the *meridian line*, I shall find it there to be equal to 4 *gr.* Wherefore I work as if the difference of latitude were 4 *gr.* and extend the compasses in the line of *numbers* from 4 vnto 6: so shall I finde

the

the same extent to reach from the tangent of 45 *gr.* vnto the tangent of 56 *gr.* 20 *m.* and this is the inclination of the Rumb required.

5 *By the Rumb and both latitudes, to find the distance vpon the Rumb.*

Extend the compasses from the sine of the complement of the Rumb, vnto the sine of 90 *gr.* the same extent in the line of *numbers* shall reach from the difference of latitude vnto the distance vpon the Rumb.

So the latitude of the first place being 50 *gr.* the latitude of the second 52 *gr.* 30 *m.* and the Rumb the fift from the meridian. If I extend the compasses from 33 *gr.* 45 *m.* vnto the sine of 90 *gr.* I shall find the same extent in the line of *numbers* to reach from 2 *gr.* 50 *cent.* to 4 *gr.* 50 *cent.* and such is the distance required.

6 *By the distance and both latitudes to find the Rumb.*

Extend the compasses in the line of *numbers* from the distance vnto the difference of latitudes; the same extent will reach in the line of *sines*, from 90 *gr.* vnto the complement of the Rumb.

So the one place being in the latitude of 50 *gr.* the other in the latitude of 52 *gr.* 30 *m.* and the distance between them 4 *gr.* 50 *cent.* If I extend the compasses from 4.50 vnto 2.50 in the line of *numbers*, I shall find the same extent to reach from the sine of 90 *gr.* vnto the complement of 56 *gr.* 15 *m.* and such is the inclination of the Rumb required.

7 *By one latitude, Rumb and distance, to find the difference of latitudes.*

Extend the compasses in the line of *sines*, from 90 *gr.* vnto the complement of the Rumb; the same extent in the line of

numbers

numbers, will reach from the distance, vnto the difference of latitudes.

So the lesser altitude being 50 *gr.* and the distance 4 *gr.* 50 *cent.* vpon the fifth Rumb from the meridian: if I extend the compasses from the sine of 90 *gr.* to 33 *gr.* 45 *m.* I shall finde the same extent to reach from 4.50 in the line of *numbers*, vnto 2.50; and therefore the second latitude to be 52 *gr.* 30 *m.*

8 *By the Rumb and both latitudes, to find the difference of longitude.*

Extend the compasses from the tangent of 45 *gr.* vnto the tangent of the Rumb; the same extent will reach in the line of *numbers* from the difference of latitudes vnto the difference of longitude, according to the proiection of the common sea-chart.

So the first latitude being 50 *gr.* and the second 52 *gr.* 30 *m.* and the Rumb the fifth from the meridian: if I extend the compasses from the tangent of 45 *gr.* vnto 56 *gr.* 15 *m.* I shall find the same extent to reach from 2.50 in the line of *numbers* to about 3.75, which make 3 *gr.* 45 *m.* But this difference of longitude so found, is alwayes lesser then it should be, and therefore to be enlarged, which may be done sufficiently for the sea-mens vse, after this maner:

Extend the compasses from the sine of the complement of the middle latitude, vnto the sine of 90 *gr.* the same extent will reach in the line of *numbers* from the difference of longitude before found, vnto the difference of longitude inlarged.

So the middle latitude in this example being 51 *gr.* 15 *m.* and the difference of longitude before found 3 *gr.* 75 *cent.* the difference of longitude inlarged will be found about 5 *gr.* 99 *cent.* which are neare 6 *gr.*

2 This difference of longitude may be found by helpe of the *meridian line* vpon the Staffe. For if I take the proper difference of latitude out of the meridian line, and measure it in his equinoctiall, or at the beginning of the meridian line,

I shall find it to be equall to foure of those degrees. Wherefore hauing extended the compasses as before from the tangent of 45 *gr.* vnto the tangent of 56 *gr.* 15 *m.* the same extent will reach from 4.00 in the line of *numbers*, vnto 5.99: which shewes the difference of longitude to be about 5 *gr.* 99 *cent.* or about halfe a minute short of six degrees.

9 *By the Rumb and both latitudes, to finde the distance belonging to the chart of* Mercators *proiection.*

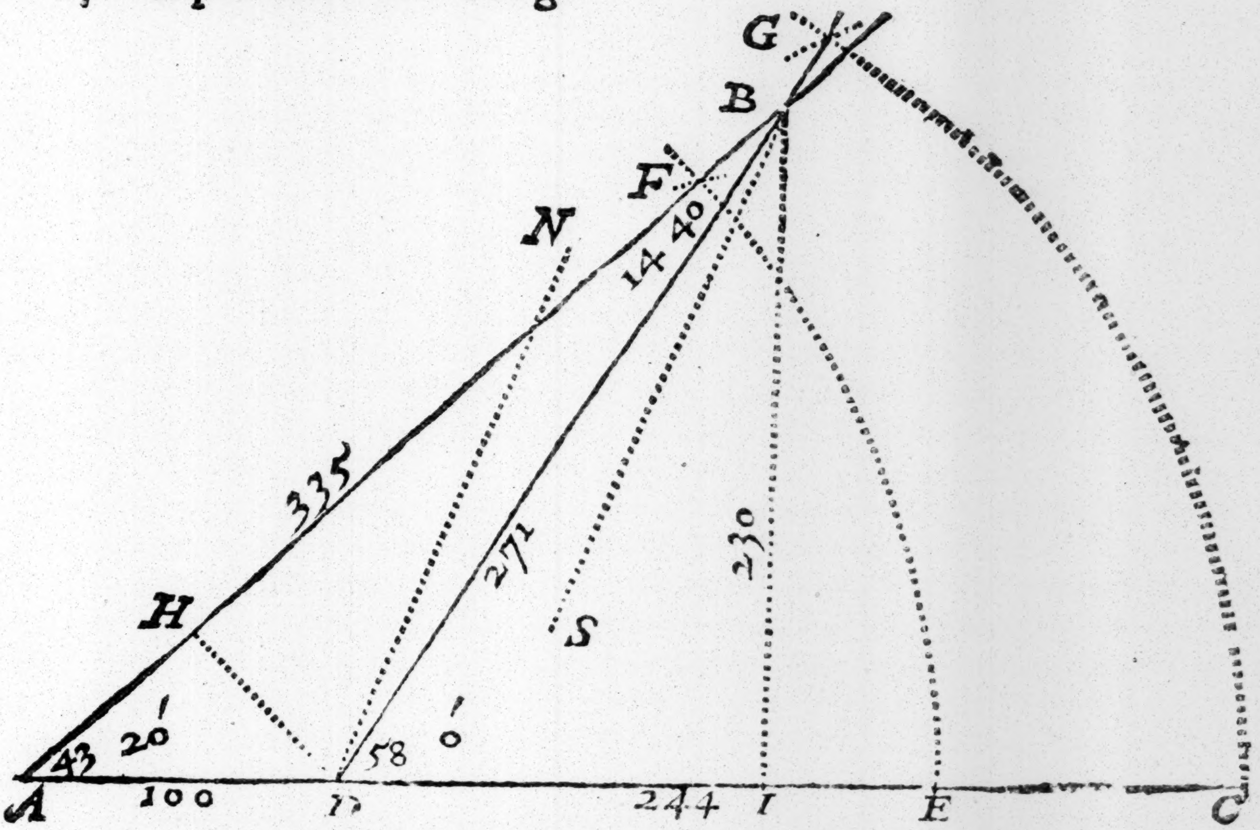
Take the proper difference of latitudes out of the meridian line of the chart, and measure it in his equinoctiall, or one of the parallels, and it will there giue the difference of latitudes inlarged. Then extend the compasses from the sine of the complement of the Rumb vnto the sine of 90 *gr.* the same extent will reach in the line of *numbers*, from the latitude inlarged, vnto the distance required. Or extend them from the complement of the Rumb to the latitude inlarged, the same extent will reach from 90 *gr.* vnto the distance.

For example, let the place giuen be *A* in the latitude of 50 *gr. D* in the latitude of 52 *gr.* 30 *m.* *A M* the difference of latitudes, and the Rumb *M A D* the fifth from the meridian. First I take out *A M* the difference of latitudes, and measure it in *A E* one of the parallels of the equinoctiall; I find it to be very neare 4 *gr*: this is the difference of latitudes inlarged. Then if I extend the compasses from the sine of 33 *gr.* 45 *m.* the complement of the fifth Rumb vnto the sine 90 *gr.* I shall find the same extent to reach in the line of *numbers* from 4.00 vnto 7.20. And this is the distance belonging to the chart. Wherefore I take out these 7 *gr.* 20 *cent.* out of the scale of the parallell *A E*, and pricke it downe vpon the Rumb from *A* vnto *D*, where it meeteth with the parallell of the second latitude. Lastly, I measure it in the *meridian line*, setting one foote of the compasses as much below the lesser latitude as the other aboue the greater latitude, and find it to be 4 *gr.* 50 *cent.* which is the same distance that I found before in the 5. *Prop.*

10 By

10 *By the way of the ship, and two angles of position, to find the distance betweene the ship and the land.*

The way of the ship may be knowne as in the first *Prop.* The angles may be obserued either by the Staffe, or by a needle set on the Staffe. For example, suppose that being at *A*, I had sight of the land at *B*, the ship going East Northeast from *A* toward *C*, and the angle of the ships position *BAC* being 43 *gr.* 20 *m:* and after that the ship had made 10 *cent.* or 2 leagues of way from *A* vnto *D*, I obserued againe, and found the second angle of the ships position *BDC* to be 58 *gr.* or the inward angle *BDA* to be 122 *gr.* then may I finde the third angle *ABD* to be 14 *gr.* 40 *m.* either by subtraction or by complement vnto 180 *gr.*



In this and the like cases, I haue a right line triangle, in which there is one side and three angles knowne, and it is required to finde the other two sides and the *Canon* for it, is this:

As the sine of the angle opposite to the knowne side,
is to that knowne side:
So the sine of the angle opposite to the side required,
is to the side required.

Wherefore I extend the compasses from 14 *gr.* 40 *m.* in the *sines*, to 10 in line of *numbers*, and this extent doth reach from 58 *gr.* to 33 $\frac{1}{3}$, and such is the distance between *A* and *B*, and it reacheth from 43 *gr.* 20 *m.* vnto 27 in the line of *numbers*; and such is the distance from *D* to *B*.

These two distances being knowne, I may set out the land vpon the chart. For hauing set downe the way of the ship from *A* to *D* by that which I shewed before in the vse of the *meridian line*, I may by the same reason set off the distance *AB* and *DB*, which meeting in the point *B*, shall there resemble the land required.

11 *By knowing the distance between two places on the land, and how they beare one from the other, and hauing the angles of position at the ship to find the distance betweene the ship and the land.*

If it may be conueniently, let the angle of position be obserued at such time as the ship cometh to be right ouer against one of the places. As if the places be East and West, seeke to bring one of them South or North from you, and then obserue the angle of position: so shall you haue a right line triangle, with one side and three angles, whereby to find the two other sides. First you haue the angle of position at the ship; then a right angle at the place that is ouer against you; and the third angle at the other place is the complement to the angle of position. Wherefore

As the sine of the angle of position,
is to the distance betweene the two places:
So the cosine of the angle of position,
to the distance betweene the ship and the nearer place.

And

And so is the sine of 90 *gr.*
to the distance from the ship to the farther place.

So the places being 15 *cent.* or three leagues one from the other, and the angle of position 29 *gr*; the nearer distance will be found about 27 *cent.* and the farther distance about 31 *cent.*

Or howsoeuer the angle of position were obserued, the distance betweene the ship and the land may be found generally as in this example:

Suppose *A* and *D* were two head lands knowne to be East Northeast, and West Southwest, 10 *cent.* or two leagues one from the other; and that the ship being at *B*, I obserued the angle of the ships position *DBA*, and found it to be 14 *gr.* 40 *m.* and that D did beare 9 *gr.* 30 *m.* and *A* 24 *gr.* 10 *m.* from the meridian *BS*, this example would be like the former. For if the angle *SBD* be 9 *gr.* 30 *m.* from the South to the Westward, then shall *NDB* be 9 *gr.* 30 *m.* from the North to the Eastward. Take these 9 *gr.* 30 *m.* out of the angle *NDE* which is 67 *gr.* 30 *m.* because the two head lands lie East Northeast, and there will remaine 58 *gr.* for the angle *BDE*, and the inward angle BDA shall be 122 *gr.* Take these two angles A B D and B D A out of 180 *gr.* and there wil remaine 43 *gr* 20 *m.* for the third angle BAD. Wherefore here also are three angles and one side, by which I may find the two other sides, as in the last *Prop.*

These propositions thus wrought by the Staffe, are such as I thought to be usefull for sea-men, and those that are skilfull may apply the example to many others. Those that begin, and are willing to practise, may busie themselues with this which followeth.

Suppose foure ports, *L*, *N*, *O*, *P*; of which *L* is in the latitude of 50 *gr.* *N* is North from *L* 200 leagues or 1000 *centesmes*; *O* West from *L* 1000 *cent.* and *P* West from *N* 1000 *cent*: so that *L* and *O* will be in the same latitude of 50 *gr.* *N* and *P* both in the latitude of 60 *gr.* Then let two ships depart from *L*, the one to touch at *O*, the other at *N*,

and then both to meet at *P*, there to lade, and from thence to returne the nearest way vnto *L*. Here many questions may be proposed.

1 What is the longitude of the port at *O*?

2 What is the longitude of *P*? And why *O* and *P* should not be in the same longitude?

3 What is the Rumb from *O* vnto *P*?

4 What is the distance from *O* vnto *P*? And why the way should be more from *L* vnto *P*, going by *O*, then by *N*?

5 What is the Rumb from *P* vnto *L*?

6 What is the distance from *P* vnto *L*?

7 What is the Rumb from *N* vnto *O*?

8 What is the distance from *N* vnto *O*? And why it should not be the like Rumb and distance from *N* vnto *O*, as from *P* vnto *L*?

These questions well considered, and either resolued by the Staffe, or pricked downe on the chart, and compared with the globe and the common Sea-chart, will giue some light to the direction of a course, and reduction of places to their due longitude, which are now fouly distorted in the common Sea-charts.

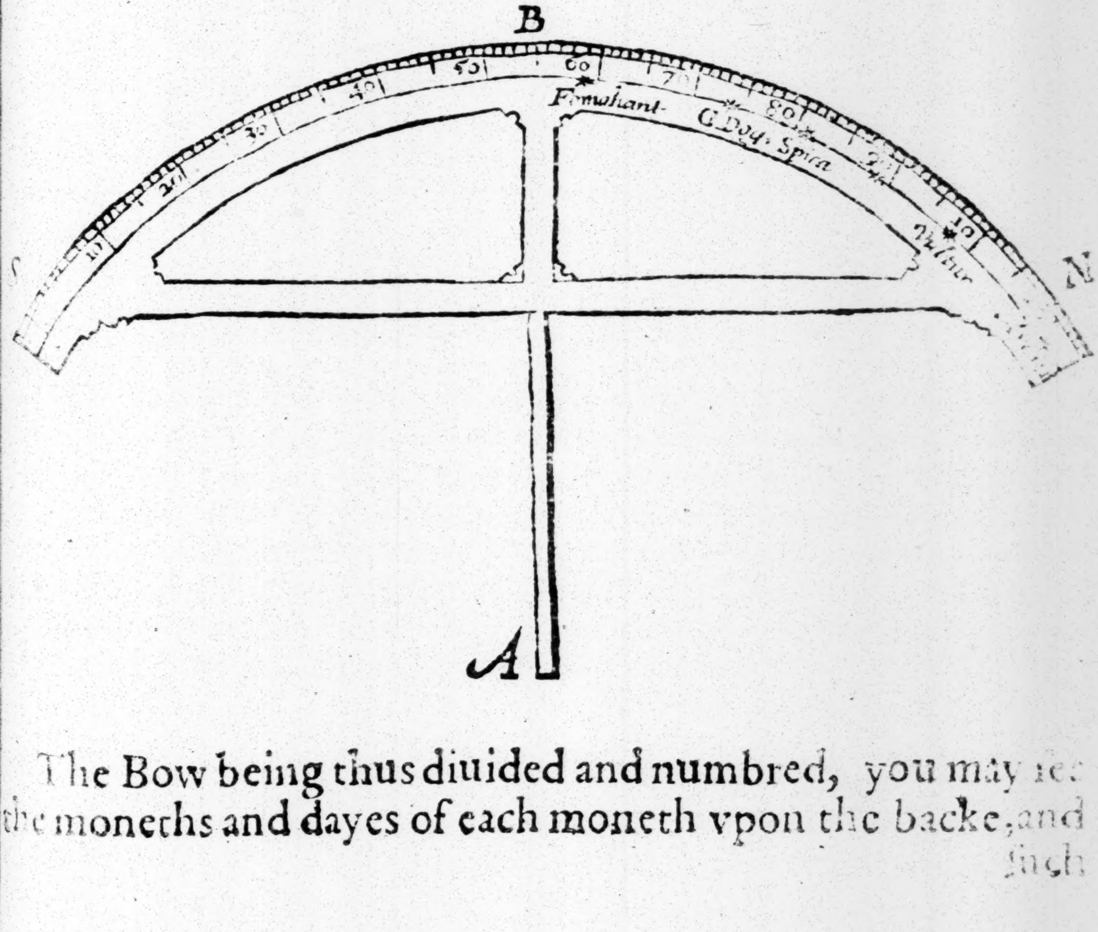
An

An Appendix concerning

The description and vse of an instrument, made in forme of a Crosse-bow, *for the more ea-sie finding of the latitude at* Sea.

THe former *Prop.* suppose the latitude to be knowne, I will here shew how it may be easily obserued.

Vpon the center *A*, and semidiameter *A B*, describe an ark of a circle *S B N*. The same semidiameter will set of 60 *gr.* from *B* vnto *S* for the South end, and other 60 *gr.* from *B* vnto *N* for the North end of the Bow: so the whole Bow will containe 120 *gr.* the third part of a circle. Let it therefore be diuided into so many degrees, and each degree subdiuided into six parts, that each part may be ten minutes: but let the numbers set to it be 5. 10. 15. vnto 90 *gr.* and then againe 5. 10. 15. vnto 25. that 55 may fall in the middle, as in this figure.



The Bow being thus diuided and numbred, you may set the moneths and dayes of each moneth vpon the backe, and

such

such starres as are fit for obseruation vpon the side of the Bow.

If you desire to make vse of it in North latitude, you may number 23 *gr.* 30 *m.* from 90 towards the end of the Bowe at N, and there place the tenth day of Iune. And 23 *gr.*30 *m.* from 90 toward *S*; and there at 66 *gr.*30 *m.* place the tenth day of December. And so the rest of the dayes of the yeare, according to the declination of the Sunne at the same dayes. The starres may be placed in like maner according to their declinations.

Arcturus at	21 *gr.*	10 *m.*
The Buls eye	15	42
The Lions heart	13	45
The Vultures heart	7	58
The little dog	6	9

from 90 toward the North end of the Bow at N. Then for Southerne starres, you may number their declination from 90 toward the South end of the Bow at *S*. As first the three starres in *Orions* girdle,

The first at	0 *gr.*	37 *m.*
The second	1	28
The third	2	11
The Hydra's heart	7	5
The virgins spike	9	10
The great dog	16	12
The Scorpions heart	25	30
Fomahant	31	30

And so the South crowne, the triangle, the clouds, the crosiers, or what other starres you think fit for obseruation. This I call the fore side of the Bow.

If you desire to make vse of it in South latitude, you may turne the Bow, and diuide the backe side of it, and number it in like maner; and then put on the moneths and dayes of the yeare, placing the tenth of December at the South end, and the tenth of Iune toward the middle of the Bow, and the rest of the dayes according to the Sunnes declination as before.

The

The chiefest of the Northerne starres may here be placed in like maner according to their declination, Anno 1625.

The pole starre at	87 *gr.*	20 *m.*
The first guard	75	45
The second guard	73	25
The great Beares backe	63	45
In the great Beares taile — first	58	2
In the great Beares taile — second	57	55
In the great Beares taile — third	51	15
The side of Perseus	48	28
The goate	45	33
The taile of the swan	44	0
The head of Medusa	39	30
The harp	38	30
Castor	32	38
Pollux	28	52
The North crowne	28	0
The Rams head	21	40
Arcturus	21	10
The Buls eye	15	42
The Lions heart	13	45
The Vultures heart	7	58
Orions right shoulder	7	17
Orions left shoulder	5	57

And so any other starre, whose declination is knowne vnto you, which being done. The vse of this Bow may be

1 *The day of the moneth being knowne, to finde the declination of the Sunne.*

2 *The declination being giuen, to finde the day of the moneth.*

These two *Prop.* depend on the making of the Bow. If the day be knowne, looke it out in the backe of the Bow: so the declination will appeare in the side. Or if the declination be knowne, the day of the moneth is set ouer against it. As if the day of the moneth were the 14 of Iuly: looke for

this day in the backe of the Bow, and you shall find it ouer against 20 *gr.* of North declination. If the declination giuen be 20 *gr.* to the Southward, you shal find the day to be either the eleuenth of Nouember, or the eleuenth of Ianuary.

3 *To find the altitude of the Sunne or starres.*

Here it is fit to haue two running sights, which may be easily moued on the backe of the Bow. The vpper sight may be set either to 60 *gr.* or to 70 *gr.* or to 80 *gr.* as you shall find to be most conuenient: the other sight may be set on, to any place betweene the middle and the other end of the Bow. Then with the one hand hold the center of the Bow to your eye, so as you may see the Sunne or starre by the vpper sight, and with the other hand moue the lower sight vp or downe vntill you haue brought one of the edges of it to be euen with the horizon (as when you obserue with the Crosse-staffe:) so the degrees contained betweene that edge and the vpper sight, shall shew the altitude required.

Thus if the vpper sight shal be at 80 *gr.* and the lower sight at 50 *gr.* the altitude required is 30 *gr.*

4 *To find any North latitude, by knowing either the day of the moneth, or the declination of the Sunne.*

As oft as you are to obserue in North latitude, place both the sights on the foreside of the Bow, the vpper sight to the declination of the Sunne, or the day of the moneth at the North end, and the lower sight toward the South end. Then when the Sunne cometh to the meridian, turne your face to the South, and with the one hand hold the center of the Bow to your eye, so as you may see the Sunne by the vpper sight; with the other hand moue the lower sight, vntill you haue brought one of the edges of it to be euen with the horizon: so that edge of the lower sight shall shew the latitude of the place in the fore side of the Bow.

Thus being in North latitude vpon the ninth of October: if

if I set the vpper sight to this day, at the fore side and North end of the Bow, I shall find it to fall to the Southward of 90 vpon 80 *gr.* and therefore at 10 *gr.* of South declination. Then the Sunne coming to the meridian, I may set the center of the Bow to mine eye, as if I went to find the altitude of the Sunne, holding the North end of the Bow vpward, with the vpper sight betweene mine eye and the Sunne, and mouing the lower sight, vntill it come to be euen with the horizon. If here the lower sight shall stay at 50 *gr.* I may well say, that the latitude is 50 *gr.* For the meridian altitude of the Sunne is 30 *gr.* by the last *Prop.* and the Sun hauing 10 *gr.* of South declination, the meridian altitude of the equator would be 40 *gr*; and therefore the obseruation was made in 50 *gr.* of North latitude.

By the same reason, if the lower side had stayed at 51 *gr.* 30 *m.* the latitude must haue been 51 *gr.* 30 *m.* and so in the rest.

5 *To find any North latitude, by the meridian altitude of the starres to the Southward.*

Let the vpper sight be set to the starre, which you intend to obserue, here placed in the fore side of the Bow. Then hold the North end of the Bow vpward, and turning your face to the South, obserue the meridian altitude as before: so the lower sight shall shew the latitude of the place in the fore side of the Bow.

Thus if in obseruing the meridian altitude of the great Dog-starre, the lower sight shall stay at 50 *gr.* it would shew the latitude to be 50 *gr.* For this starre being here placed at 73 *gr.* 48 *m.* if we take thence 50 *gr.* his meridian altitude would be 23 *gr.* 48 *m.* to this if we adde 16 *gr.* 12 *m.* for the South declination of this starre, it would shew the meridian altitude of the equator to be 40 *gr.* and therefore the latitude to be 50 *gr.*

6 To find any North latitude, by the meridian altitude of the starres to the Northward.

Let the vpper sight be set to the starre which you intend to obserue, here placed on the backe side of the Bow. Then hold the North end of the Bow vpward, and turning your face to the North, obserue the altitude of the starre when he cometh to be in the meridian and vnder the pole: so the lower sight shall shew the altitude of the pole in the back side of the Bow.

Thus the former guard coming to be in the meridian vnder the pole, if you obserue and find the lower sight to stay at 50 *gr.* such is the eleuation of the pole, and the latitude of the place to the Northward. For the distance betweene the two sights will shew the altitude to be 35 *gr.* 45 *m.* & the star is 14 *gr.* 15 *m.* distant from the North pole. These two doe make vp 50 *gr.* for the eleuation of the North-pole, and therefore such is the North latitude.

7 To find any South latitude, by knowing either the day of the moneth, or the declination of the Sunne.

When you are come into South latitude, turne both your sights to the backside of the Bow: the vpper sight to the declination of the Sun, or the day of the moneth at the South end, and the lower sight toward the North end of the Bow. Then the Sunne coming to the meridian, turne your face to the North, and holding the South end of the Bow vpward, obserue the meridian altitude as before: so the lower sight shall shew the latitude of the place in the backe side of the Bow.

Thus being in South latitude, vpon the tenth of May if you obserue and finde the lower sight to stay at 30 *gr.* on the backe side of the Bow, such is the latitude. For the declination is 20 *gr.* Northward, the altitude of the Sunne betweene the two sights 40 *gr.* the altitude of the equator 60 *gr.* and there-

therefore the latitude 30 *gr.*

8 *To find any South latitude, by the meridian altitude of the starres to the Northward.*

Let the vpper sight be set to the starre which you intend to obserue, here placed on the backe side of the Bow. Then hold the South end of the Bow vpward, and turning your face to the North, obserue the meridian altitude as before: so the lower sight shall shew the latitude of the place in the back side of the Bow.

Thus being in South latitude, and the former guard comming to be in the meridian ouer the pole. If you obserue and finde the lower sight to stay at 5 *gr.* such is the latitude. For this starre is 14 *gr.* 15 *m.* from the North pole, the altitude of the starre betweene the two sights 9 *gr.* 15 *m.* the North pole depressed 5 *gr.* and therefore the latitude 5 *gr.* to the Southward.

9 *To obserue the altitude of the Sunne backward.*

Set the vpper sight either to 60, or 70, or 80 *gr.* as you shall find it to be most conuenient, the lower sight on any place betweene the middle and the other end of the Bow, and haue an horizontall sight to be set to the center. Then may you turne your backe to the Sunne, and the back of the Bow toward your selfe, looking by the lower sight through the horizontall sight, and mouing the lower sight vp & downe, vntill the vpper sight doe cast a shadow vpon the middle of the horizontall sight: so the degrees contained betweene the two sights on the Bow, shall giue the altitude required.

Thus if the vpper sight shall be at 80 *gr.* and the lower sight at 50 *gr.* the altitude required is 30 *gr.* as in the third *Prop.*

10 *To find any North latitude by a backe obseruation, knowing either the day of the moneth, or the declination of the Sunne.*

When you obserue in North latitude, place your three sights on the fore side of the Bow: the vpper sight to the declination of the Sun, or the day of the moneth, at the North end; the lower sight toward the South end of the *Bow*; and the horizontall sight to the center. Then the Sunne comming to the meridian, turne your face to the North, & holding the North end of the *Bow* vpward, the South end downeward, with the back of it toward your selfe, obserue the shadow of the vpper sight as in the former *Prop.* so the lower sight shall shew the latitude of the place in the fore side of the *Bow*.

Thus being in North latitude vpon the ninth of October, if you obserue and find the lower sight to stay at **50** *gr.* on the fore side of the Bow, such is the latitude. For the declination is 10 *gr.* Southward, and the altitude of the Sunne betweene the two sights 30 *gr.* the altitude of the equator 40 *gr.* and therefore the latitude 50 *gr.* as in the fourth *Prop.*

11 *To find any South latitude by a back obseruation, knowing either the day of the moneth, or the declination of the Sunne.*

When you obserue in South latitude, place your three sights on the backe side of the Bow: the vpper sight to the declination of the Sunne, or the day of the moneth at the South end; the lower sight toward the North end of the Bow, and the horizontall sight to the center. Then the Sun comming to the meridian, turne your face to the South, and holding the South end of the Bow vpward, with the backe of it toward your selfe, obserue the shadow of the vpper sight as before: so the lower sight shal shew the latitude of the place in the back side of the Bow.

Thus being in the South latitude vpon the tenth of May,

you obserue and find the lower sight to stay at 30 *gr.* on the backe of the Bow, such is the altitude. For the declination 20 *gr.* Northward, the altitude of the Sunne betweene the two sights 40 *gr.* the altitude of the equator 60 *gr.* and therefore the latitude 30 *gr.* as in the seuenth *Prop.*

12 *To find the day of the moneth, by knowing the latitude of the place, and obseruing the meridian altitude of the Sunne.*

Place your three sights according to your latitude; the horizontall sight to the center, the lower sight to the latitude, and the vpper sight among the moneths. Then when the Sunne cometh to the meridian, obserue the altitude, looking by the lower sight through the horizontall, and keeping the lower sight still at the latitude, but mouing the vpper sight vntil it giue shadow vpon the middle of the horizontal sight: the vpper sight shall shew the day of the moneth required.

Thus in our latitude if you set the lower sight to 51 *gr.* 30 *m.* and obseruing finde the altitude of the Sunne betweene that and the vpper sight to be 28 *gr.* 30 *m.* this vpper sight will fall vpon the ninth of October, and the twelfth of Februarie. And if yet you doubt which of them two is the day, you may expect another meridian altitude; and then if you find the vpper sight vpon the tenth of October, and the eleuenth of Februarie, the question will be soone resolued.

13 *To find the declination of any vnknowne starre, and so to place it on the Bow, by knowing the latitude of the place, and obseruing the Meridian altitude of the Starre.*

When you find a starre in the Meridian that is fit for obseruation. Set the center of the Bow to your eye, the lower sight to the latitude, and moue the vpper sight vp or downe till you see the horizon by the lower sight, and the starre

by

by the vpper sight, then will the vpper sight stay at the decli-
nation and place of the starre.

Thus being in 20 *gr.* of North latitude, if you obserue and find the meridian altitude of the head of the Crosier to be 24 *gr.* 50 *m.* The vpper sight will stay at 34 *gr* 50 *m.* and then may you place this starre. For by this obseruatiō the distance of this starre from the South pole should be 34 *gr.* 50 *m.* and the declination from the equator 55 *gr.* 10 *m.* And so for the rest.

The starres which I mention here before, do come to the meridian in this order, after the first point of *Aries.*

	Ho.	*Mi.*		*Ho.*	*Mi.*
The pole starre at	0	29	The lions hart	9	48
The rams head	1	46	The great beares backe	10	40
The head of Medusa	2	44	First in gr. beares taile	12	37
The side of Perseus	2	58	The Virgins spike	13	5
The Buls eye.	4	15	Second in gr. beares taile	13	9
The goate	4	49	Third in gr. beares taile	13	33
Orions left shoulder	5	5	Arcturus	13	58
Orions girdle the first	5	13	The formost guard	14	52
Orions girdle the second	5	17	The North crowne	15	19
Orions girdle the third.	5	22	The hindmost guard	15	25
Orions right shoulder	5	35	Scorpions hart	16	7
The great dog	6	29	The harpe	18	24
Castor	7	10	Vulturs hart	19	33
The little dog	7	20	Swans taile	20	29
Pollux	7	22	Fomahang	22	36
The Hydra's hart	9	9			

The end of the second Booke.

THE THIRD BOOKE.

Of the vſe of the lines of Numbers, Sines and Tangents for the drawing of Houre-lines on all ſorts of Planes.

THere are ten ſeuerall ſorts of Planes, which take their denomination frõ thoſe great circles to which they are parallels, and may ſufficiently for our vſe be repreſented in this one fundamentall Diagram deſcribed before in the vſe of the *Sector*, and be knowne by their horizontall and perpendicular lines, of ſuch as know the latitude of the place, and the circles of the ſphere.

1 An horizontall plane parallell to the horizon, here repreſented by the outward circle *E S W N*.

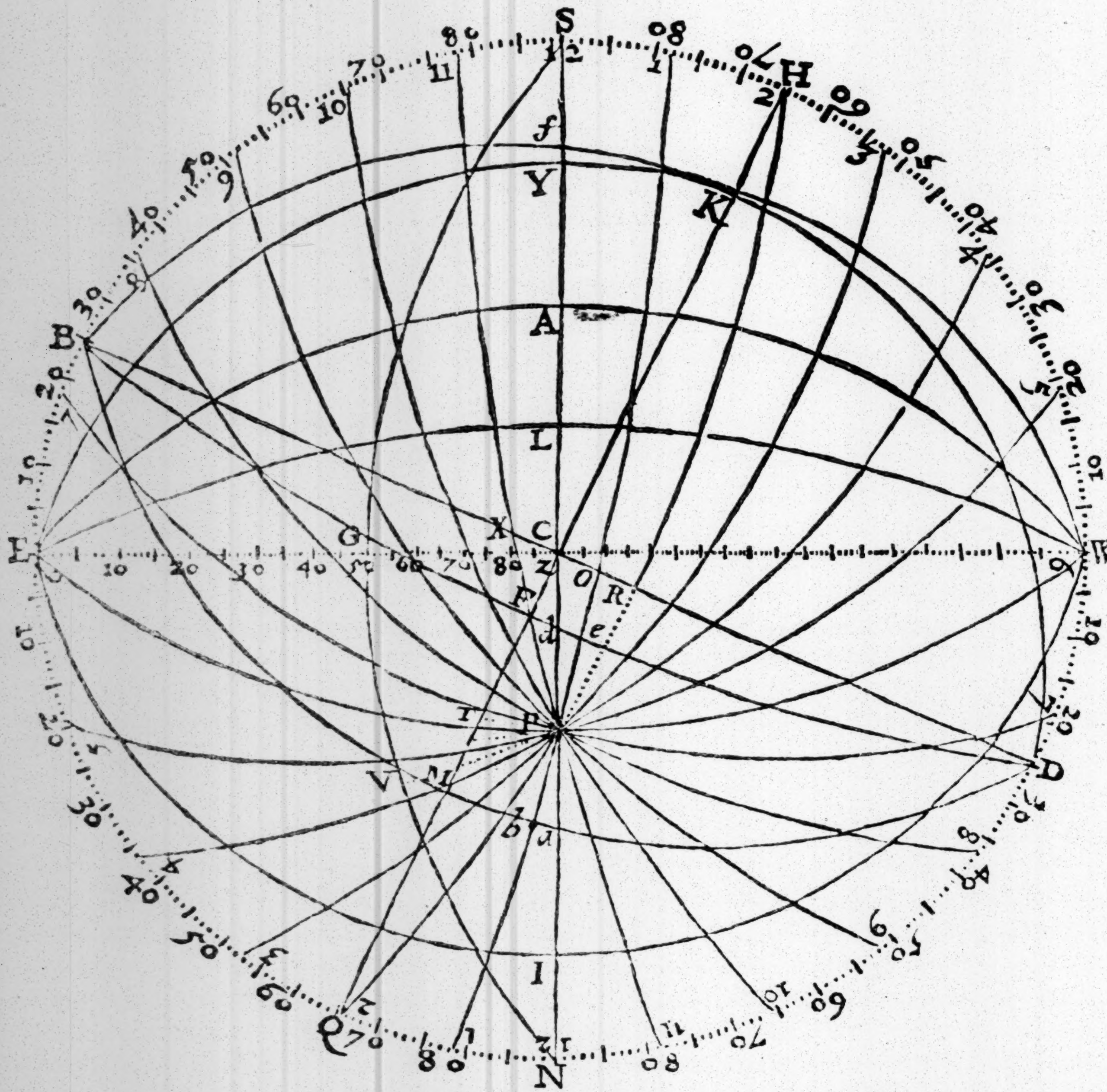
2 A verticall plane parallell to the prime verticall circle which paſſeth through the zenith and the points of Eaſt and Weſt in the horizon, and is right to the horizon and the meridian; that is, maketh right angles with them both. This is repreſented by *E Z W*.

3 A polar plane parallell to the circle of the houre of 6, which paſſeth through the pole and the points of Eaſt and Weſt, being right to the Equinoctiall and the Meridian, but inclining to the horizon, with an angle equall to the latitude. This is here repreſented by *E P W*.

4 An equinoctiall plane parallell to the Equinoctiall, which paſſeth through the points of Eaſt and Weſt, being right to the Meridian, but inclining to the Horizon, with an angle equall to the complement of the latitude. This is here repreſented by *E A W*.

5 A verticall plane inclining to the horizon, parallell to any great circle, which paſſeth through the points of Eaſt and Weſt, being right to the meridian, but inclining to the horizon, and yet not paſſing through the pole, nor parallell

 to



to the equinoctiall. This is here represented either by *E I W*, or *E Y W*, or *E L W*.

6 A meridian plane parallell to the meridian, the circle of the houre of 12, which passeth through the zenith, the pole, and the points of South and North, being right to the horizon, and the prime verticall. This is here represented by *S Z N*.

7 A meridian plane inclining to the horizon, parallell to any great circle, which passeth through the points of South and North, being right to the prime verticall, but inclining

clining to the horizon. This is here represented by *S G N.*

8 A verticall declining plane, parallell to any great circle, which passeth through ỹ zenith, being right to the horizon, but inclining to the meridian. This is represented by *BZD.*

9 A polar declining plane, parallell to any great circle, which passeth through the pole, being right to the equinoctiall, but inclining to the meridian. This is here represented by *H P Q.*

10 A declining inclining plane, parallell to any great circle, which is right to none of the former circles, but declining from the prime verticall, and inclining both to the horizon and the meridian, and all the houre circles. This may be here represented either by *B M D*, or *B F D*, or *B K D*, or any such great circle, which passeth neither through the South and North, nor East and West points, nor through the zenith nor the pole.

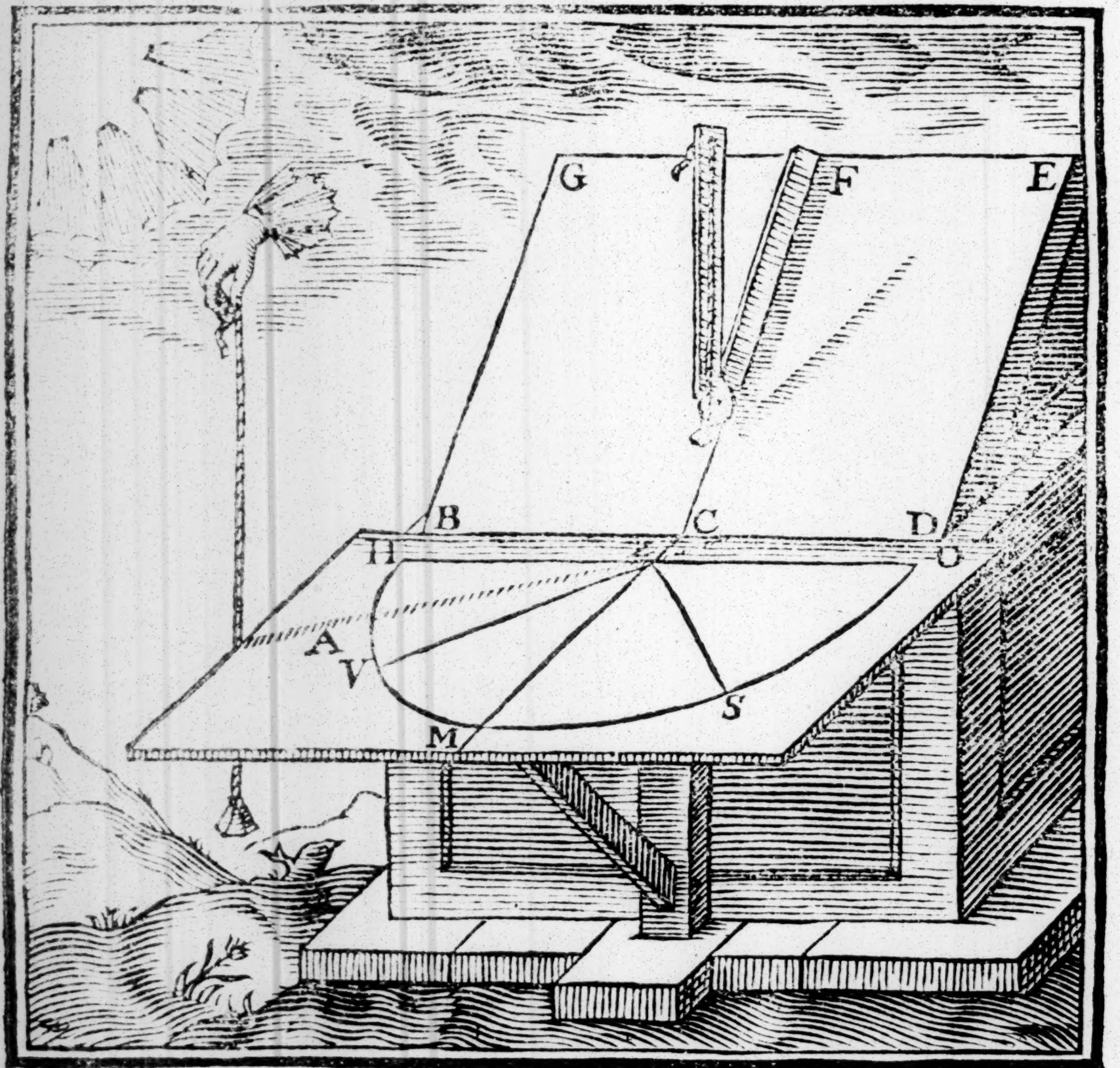
Each of these planes (except the horizontall) hath two faces whereon houre-lines may be drawne; and so there are 19 planes in all. The meridian plane hath one face to the East, and another to the West: the other verticall planes haue one to the South, and another to the North, and the rest one to the zenith, and another to the nadir: but what is said of the one, may be vnderstood of the other.

To find the inclination of any Plane.

For the distinguishing of these Planes we may finde whether they be horizontall, or verticall, or inclining to the horizon, and how much they incline, either by the vsuall inclinatorie quadrant, or by fitting a thread and plummet vnto the *Sector*.

For let the *Sector* be opened to a right angle, the lines of *Sines* to an angle of 92 *gr.* the inward edges of the *Sector* to 90 *gr.* and let a thread and plummet be hanged vpon a line parallell to the edges of one of the legs, so that leg shall be verticall, and the other leg parallell to the horizon.

If the plane seeme to be verticall (like the wall of an vp-



right building) you may trie it by holding the *Sector*, ſo that the thread may fall vpon his plummet line. For then if the verticall edge of the *Sector* ſhall lie cloſe to the plane, the plane is erect, and therefore ſaid to be verticall; and if you draw a line by that edge of the *Sector*, it ſhall be a verticall line.

If the plane ſeeme to be leuell with the horizon, you may trie it by ſetting the horizontall leg of the Sector to the plane, and holding the other leg vpright: for then if the thread ſhall fall on his plummet line, which way ſoeuer you turne the *Sector*, it is an horizontall plane.

If the one end of the plane be higher then the other, and yet not verticall, it is an inclining plane, and you may find the inclination in this maner.

First

First hold the verticall leg of the Sector vpright, and turne the horizontall leg about, vntill it lie close with the plane, and the thread fall on his plũmet line: so the line drawne by the edge of that horizontall leg, shall be an horizontall line.

Suppose the plane to be *B G E D*, and that *B D* were thus found to be the horizontall line vpon the plane; then may you crosse the horizontall line at right angles with a perpendicular *C F*: that done, if you set one of the legs of the *Sector* vpon the perpendicular line *C F*, and make the other leg with a thread and plummet to become verticall, you shal haue the angle betweene the verticall line and the perpendicular on the Plane, as before in the vse of the *Sector*, pag. 50. and the complement of this angle is the inclination of the plane to the horizon.

To find the declination of a Plane.

The declination of a Plane is alwayes reckoned in the horizon betweene the line of East and West, and the horizontall line vpon the Plane. As in the fundamentall Diagram, the prime verticall line (which is the line of East and West) is *E C W*; if the horizontall line of the plane proposed shal be *B C D*, the angle of declination is *E C B*.

But because a Plane may decline diuers wayes, that we may the better distinguish them, we consider three lines belonging to euery Plane: the first is the horizontall line; the second the perpendicular line, crossing the horizontall at right angles; the third the axis of the plane, crossing both the horizontall line, and his perpendicular, and the plane it selfe at right angles.

The perpendicular line doth help to find the inclination of the plane as before, the horizontall to finde the declination, the axis to giue denomination vnto the plane.

For example, in a verticall plane here represented by *E Z W*, the horizontall line is *E C W*, the same with the line of East and West, and therefore no declination; the perpendicular crossing it, *C Z* the same with the verticall line,

drawne from the center to the zenith, right vnto the horizon, and therefore no inclination. The axis of the plane is *S C N*, the same with the meridian line, drawne from the South to the North, and accordingly giues the denomination to the plane. For the plane hauing two faces, and the axis two poles, *S* and *N*; the pole *S* falling directly into the South, doth cause that face to which it is next to be called the South face; and the other pole at *N*, pointing into the North, doth giue the denomination to the other face, and make it to be called the North face of this plane.

In like maner in the declining inclining plane here represented by *B F* D, the horizontall line is *B C* D, which crosseth the prime verticall line *E C W*, and therefore it is called a declining plane, according to the angle of declination *E C B* or *W C* D. The perpendicular to this horizontall line is *C F*, where the point *F* falleth in the plane *Q Z H* perpendicular to the plane proposed, betweene the zenith and the North part of the horizon, and therefore it is called a plane inclining to the Northward, according to the arke *F Q*, or the angle *F C Q*. The axis of the plane is here represented by the line *C K*, where the pole *K* is 90 *gr.* distant from the plane, and so is as much aboue the horizon at H, and the other pole as much below the horizon at *Q*, as the plane at *F* is distant from the zenith: and this pole *K* here falling betweene the meridian and the prime verticall circle into the Southwest part of the world, this vpper face of the plane is therefore called the Southwest face, and the lower the Northeast face of the plane.

The declination from the prime verticall may be found by the needle in the visuall inclinatorie Quadrant, or rather by comparing the horizontall line drawne vpon the plane with the azimuth of the Sunne and the meridian line, in such sort as before we found the variation of the magneticall needle. For take any boord that hath one side strait, and draw the line H O parallell to that side, and the line *Z M* perpendicular vnto it, and on the center *Z* make a semicircle *H M* O: this done, hold the boord to ẏ plane, so as H O may be

be parallel to B D the horizontall line on the plane and the boord parallell to the horizon; then the Sunne shining vpon it, hold out a thread and plummet, so as the thread being verticall, the shadow of the Sunne may fall on the center *Z*, and draw the line of shadow *A Z* representing the common section, which the azimuth of the Sunne makes with the plane of the horizon, and let another take the altitude of the Sunne at the same instant: so by resoluing a triangle, as I shewed before pag. *65*. you may find what azimuth the Sun was in when he gaue shadow vpon *A Z*.

Suppose the azimuth to be (as before pag. *64*.) 72 *gr*. 52 *m*. from the North to the Westward, and therefore 17 *gr*. 8 *m*. from the West, we may allow these 17 *gr*. 8 *m*. from *A* vnto *V*, and draw the line *Z V*, and so we haue the true West point of the prime verticall line: then allowing *90 gr*. from *V* vnto *S*, we haue the South point of the meridian line *Z S*, and the angle H Z V shall giue the declination of the plane from the verticall, and the angle *O Z S* the declination of the plane from the meridian.

Or we may take out onely the angle A Z H, which the line of shadow makes with the horizontall line of the plane, and compare it with the angle *A Z V*, which the line of shadow makes with the prime verticall. And so here if *A Z V* the Sunnes azimuth shall be 17 *gr*. 8 *m*. past the West, and yet the line of shadow *A Z* 7 *gr*. 12 *m*. short of the plane, the declination of the plane shall be 24 *gr*. 20 *m*. as may appeare by the site of the plane and the circles.

If the altitude of the Sunne be taken at such time as the shadow of the thread falleth on B D or H O, and then a triangle resolued, the declination of the plane will be such as the azimuth of the Sunne from the prime verticall.

If at such a time as the shadow falleth on *M Z*, the declination will be such as the azimuth of the Sunne from the meridian.

If it be a faire Summers day you may first finde what altitude the Sunne will haue when he cometh to be due East or West, and then expect vntill he come to that altitude; so the

de-

declination of the plane ſhall be ſuch as the angle contained betweene the line H O and the line of the ſhadow.

Hauing diſtinguiſhed the Planes, the next care will be for the placing of the ſtyle and the drawing of the houre-lines.

The ſtyle will be as the axis of the world, ſometimes parallell to the plane, ſometimes perpendicular, ſometimes cut the plane with oblique angles.

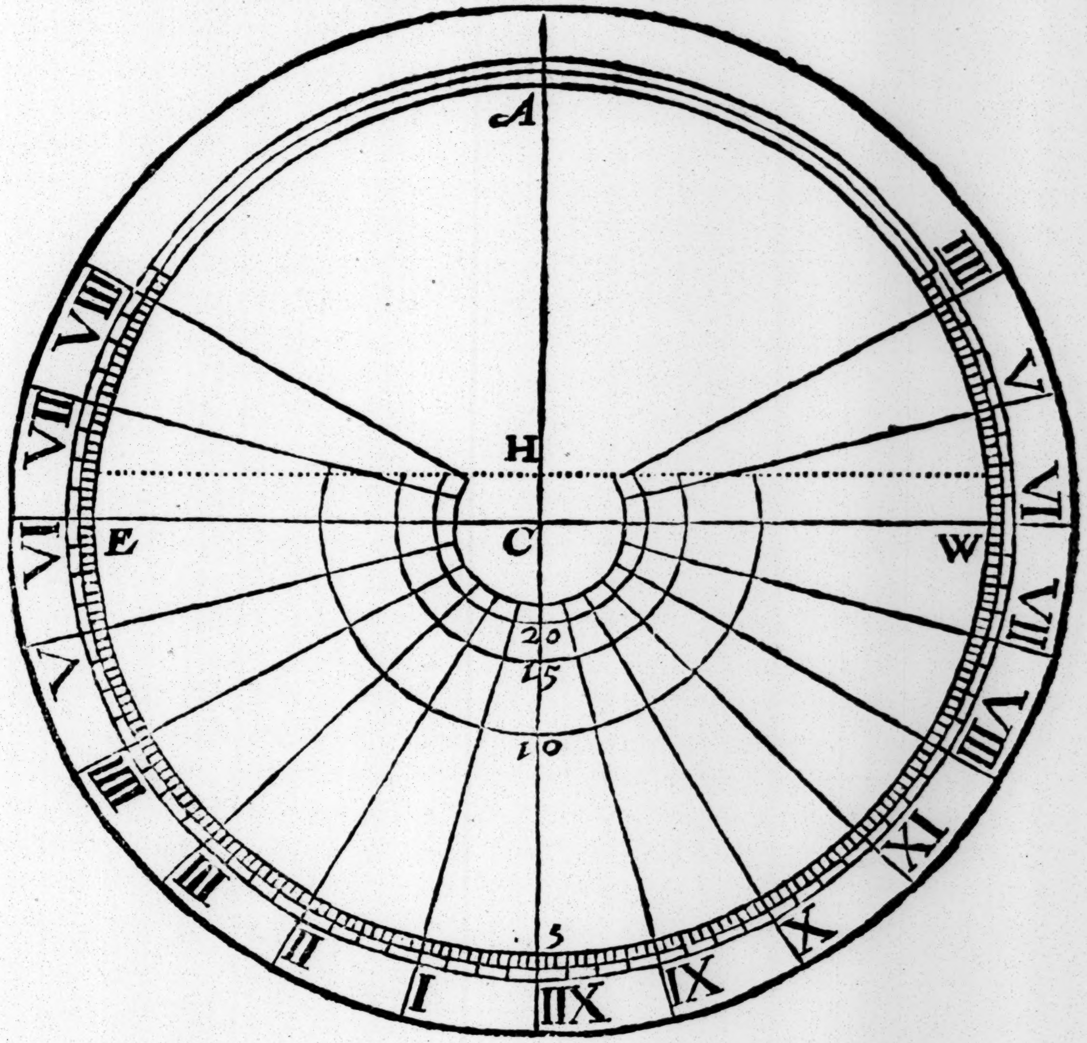
The houre-lines will be either parallell one to the other, or meete in a center with equall angles, or meete with vnequall angles. If the ſtyle be perpendicular to the plane, the angles at the center will be equall; and this falls out onely in the South and North face of an equinoctiall plane: if the ſtyle be parallell to the plane, the houre-lines wil be alſo parallell one to another; and this falls out in all polar planes; as in the Eaſt and Weſt meridian planes parallel to the circle of the houre of 12, in the vpper and lower direct polars parallell to the circles of the houre of 6, and in the vpper and lower declining polars which are parallell to any of the other houre circles.

But in the horizontall and all other planes, the ſtyle will cut the plane with an acute angle, and the houre lines will meet at the root of the ſtyle, and there make vnequall angles.

CHAP. I.

To draw the houre-lines in an equinoctiall Plane.

AN equinoctiall plane is that which is parallell to ẏ equinoctiall circle here repreſented by *EAW*, wherein the ſpaces betweene the houre circles being equall, there is no need of further precept, but onely to draw a circle and to diuide it into 24 equall parts for the 24 houres, and ſubdiuide each houre into halues and quarters, and then to ſet vp the

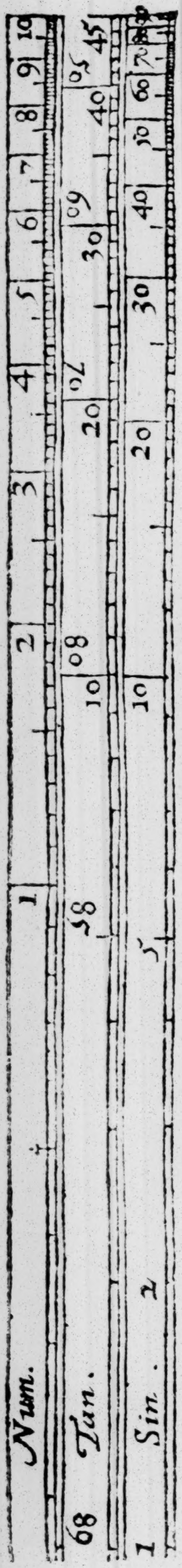


the ſtyle perpendicular to the plane in the center of the circle. The help which theſe lines of proportion doe here affoord vs, is onely in the diuiſion of the circle, which may be done readily by that which I ſhewed before, *Pag.* 29.

For example, ſuppoſe the ſemidiameter of the equinoctiall circle to be ſix inches, and that it were required to know the diſtance of the houre-points each from other: here each houre being 15 *gr.* diſtant from other, I extend the compaſſes from the ſine of 30 *gr.* vnto the ſine of 7 *gr.* 30 *m.* the halfe of 15 *gr.* and I find the ſame extent to reach in the line of numbers from 6.00 vnto 1.56.

Or in croſſe worke I extend them from the ſine of 30 *gr.* vnto 6.00 in the line of numbers, the ſame extent will reach from the ſine of 7 *gr.* 30 *m.* vnto 1.56 in the line of numbers; which ſhewes that in a circle of ſix inches ſemidiameter, the

n distance



diſtance of the houre-points each from other will be about 1 inch and 56 denteſmes or parts of 100. The like reaſon holds for the inſcribing of all other chords in the *Prop.* following.

CHAP. II.

To draw the houre-lines in a direct polar plane.

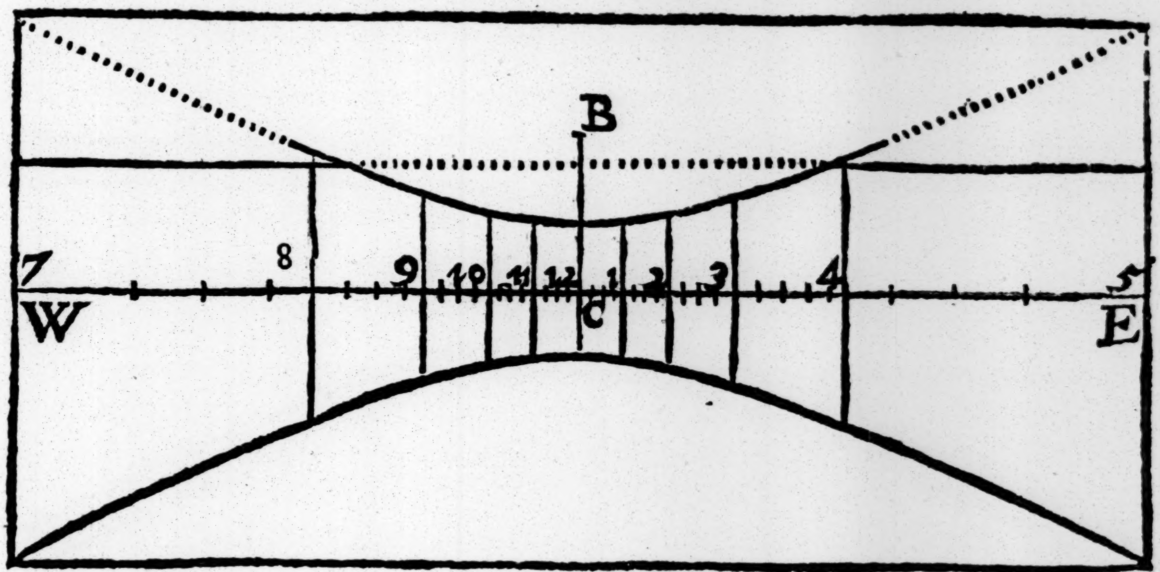
A Direct polar plane is that which is parallell to the houre of 6, here repreſented by *E P W*, wherein the ſtyle will be parallell to the plane, and the houre-lines parallell one to the other, and therefore may be beſt drawne by that which I haue ſhewed in the vſe of the *Sector.* They may be alſo drawne by the helpe of theſe lines of proportion, in this maner.

Firſt draw a right line *W E* for the horizon and the equator, and croſſe it at the point *C*, about the middle of the line with *C B* another right line, which may ſerue for the meridian and the houre of 12, and muſt alſo be the ſubſtylar line wherein the ſtyle ſhall ſtand. Then, to proportion the ſtyle vnto the plane, conſider the length of the horizontall line, and what houre-lines you would haue to fall on your plane.

For the diſtance of any one houre-line from the meridian being knowne, we may finde both the length of the ſtyle and the diſtance of the reſt: becauſe

As the tangent of the houre giuen,
 is to the diſtance from the meridian:
So the tangent of 45 *gr.*
 to the height of the ſtyle.

Suppoſe



Suppose the length of the horizontall line to be 12 inches, and that it were required to put on all the houre-lines from 7 in the morning vnto 5 in the euening. Here we haue 5 houres and 6 inches on either side the meridian. Wherefore I allow 15 *gr.* for an houre, and extending the compasses the compasses from the tangent of 75 *gr.* the measure of 5 houres vnto the tangent of 45 *gr.* I find the same extent to reach in the line of numbers from 6.00 to about 1.61. This shewes both the height of the style, and the distance of the houre-points of 9 & 3 frō the meridian to be 1 inch, 61 parts.

To find the length of the Tangent betweene the substylar and the houre-points.

As the tangent of 45 *gr.*
to the tangent of the houre:
So the height of the style
to the length of the tangent line betweene the substylar and the houre-points.

Thus hauing found the length of the style in our example to be 1.61, if I exend the compasses from the tangent of 45 *gr.* vnto the tangent of 15 *gr.* the measure of the first houre from the substylar, I shall find the same extent to reach in the line of numbers from 1.61 vnto 0.43 for the length of the

tangent betweene the subſtylar and the houre-points of 11 and 1. If I extend them from the tangent of 45 *gr.* vnto the tangent of 75 *gr.* the meaſure of the fift houre, I ſhall finde them to reach in the line of numbers from 1.61 vnto 6.00 for the length of the tangent from the ſubſtylar to the houre-points of 7 and 5. For howſoeuer it be the ſame diſtance in the line of tangents from 45 vnto 75, as from 45 vnto 15; yet becauſe 75 are more, and 15 leſſe then 45, the tangent lines that anſwer to them wil be accordingly more or leſſe then the length of the ſtyle.

Ho.	An. Po		Tang.	
	Gr.	*M.*	In.	Par
12	0	0	0	0
11. 1	15	0	0	43
10. 2	30	0	0	93
9. 3	45	0	1	61
8. 4	60	0	2	79
7. 5	75	0	6	0
6. 6	90	0	Infin	

Againe, if I extend them from 45 *gr.* in the tangents vnto 30 *gr.* the meaſure of the ſecond houre, I ſhall finde them to reach in the line of numbers from 1.61 vnto 0.93 for the houre of 10 and 2: if I extend them from the tangent of 45 *gr.* vnto the tangent of 60 *gr.* for the fourth houre, I ſhal find them to reach in the line of numbers from 1.61 vnto 2 79, and ſuch is the length of the tangent line from the ſubſtylar vnto the houre of 8 and 4. And the like reaſon holdeth for the inſcribing of all other tangent lines in the propoſitions following.

But for ſuch tangents as fall vnder 45 *gr.* I may better vſe croſſe worke, and extend the compaſſes from the tangent of 45 *gr.* vnto 1.61 in the line of numbers, ſo ſhall I finde the ſame extent to reach from 30 *gr.* in the tangents, to 93 parts in the line of numbers, for the diſtance of the ſecond houre, and from 15 *gr.* in the tangents to 43 parts for the diſtance of the firſt houre from the meridian.

Or if this extent from 45 *gr.* backward to 1.61 be too large for the compaſſes, I may extend forward from the tangent of 5 *gr.* 43 *m.* to 1.61 parts in the line of numbers, and the ſame extent ſhall reach from 15 *gr.* in the tangents, to 43 parts in the line of numbers, for the diſtance of the firſt houre; and from 30 *gr.* to 93 parts, for the diſtance of the ſecond houre, as before.

Hauing

Hauing found the length of the tangent lines in inches and parts of inches, and pricked them in the equator on both ſides of the meridian, from the center *C*; if wee draw right lines through each of thoſe points, croſſing the equator at right angles, they ſhall be the houre-lines required; and if we ſet a ſtyle ouer the meridian, ſo as the edge of it be parallell to the plane, and the height of it be as much aboue the meridian as the diſtance between the meridian and the houre-points of 3 or 9, it ſhall repreſent the axis of the world, and be truly placed for the caſting of the ſhadow vpon the houre-lines in a polar plane.

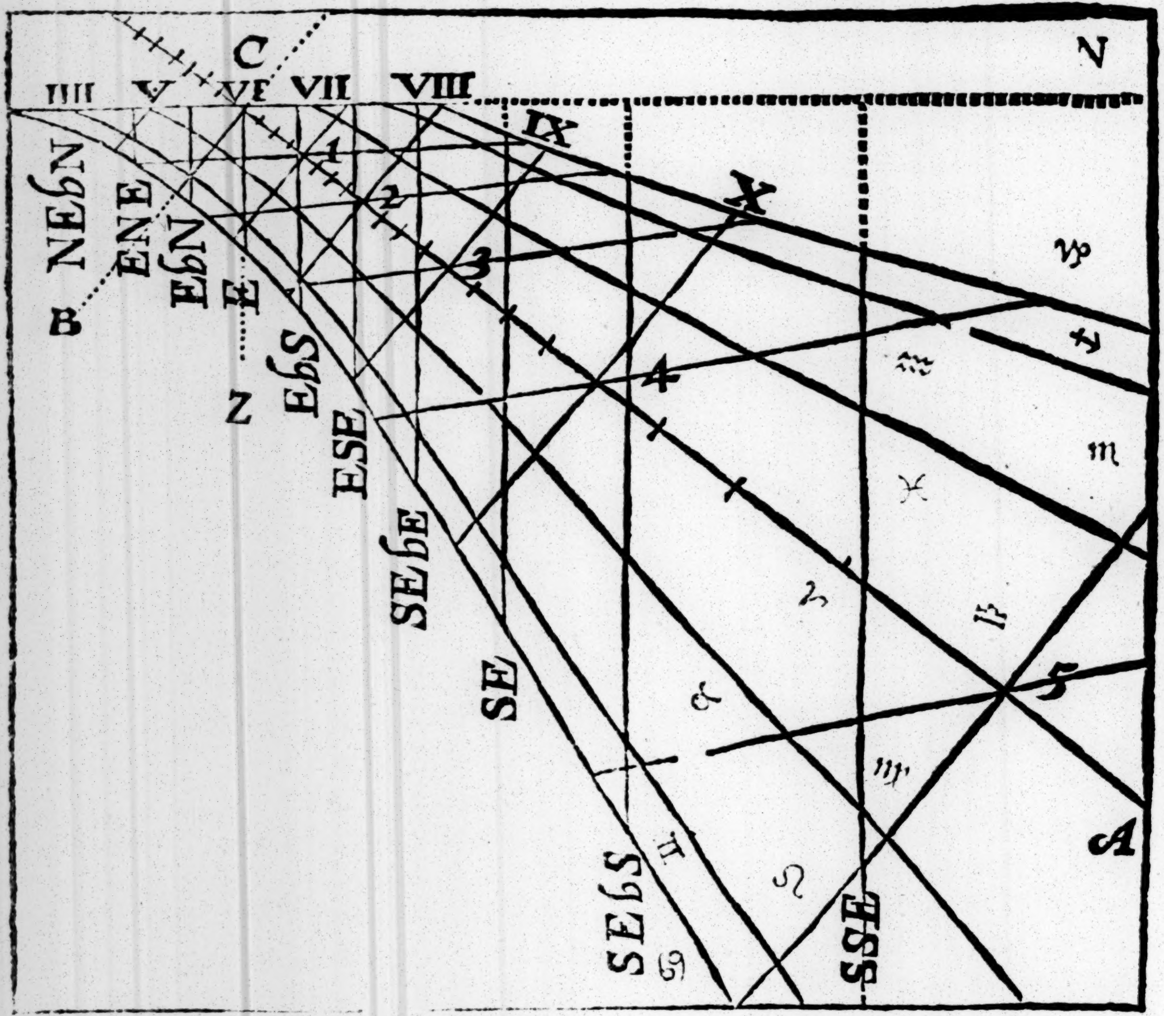
Horæ	Ang.Po		Tang	
	Gr.	M.	In.	Pa
6		0		0
	3	45		65
	7	30	1	32
	11	15	1	99
7	15	0	2	68
	18	45	3	39
	22	30	4	14
	26	15	4	93
8	30	0	5	77
	33	45	6	68
	37	30	7	67
	41	15	8	77
9	45	0	10	00
	48	45	11	40
	52	30	13	03
	56	15	14	97
10	60	0	17	32
	63	45	20	28
	67	30	24	14
	71	15	29	46
11	75	0	37	32
	78	45	50	27
	82	30	75	96
	86	15	152	57
12	90	0	Infin.	

CHAP. III.

To draw the houre-lines in a meridian plane.

A Meridian plane is that which is parallell to the meridian circle here repreſented by *S Z N*; it hath two faces, one to the Eaſt, and the other to the Weſt; in each of them the ſtyle will be parallell to the plane, and the houre-lines parallell one to the other, as in a polar plane, the difference being onely in the placing of the equator & in numbring of the houres.

For in theſe meridian planes hauing drawn an occult verticall line *C Z*, and an occult horizontall line *C N*, croſſing one the other at right angles in the point *C*, the equator *A C* wil cut the verticall with an angle *Z C A*, equall to the latitude of the place: then may we croſſe the equator at right angles with the line *C B* for the houre of 6, and from this ſet off the



houre-points in the equator as in the former *Prop.*

For ſuppoſing the length of the ſtyle *C B* to be ten inches, the length of the tangent line belonging to the firſt houre wil be 2 *in.*68 *p.* the length of the ſecond 5 *in.*77 *p.* as in the Table. Then the tangent of 15 *gr.*being prickt downe in the equator on both ſides from 6, ſhal ſerue for the houres of 5 and 7, and the tangent of 30 *gr.*for the houres of 4 and 8, and ſo in the reſt. This done, if we draw right lines through each of theſe points, croſſing the equator at right angles, they ſhall be the houre-lines required: and if we ſet a ſtyle ouer the houre of 6, ſo as the edge of it may be parallell to the plane, and the height of it may be equall to the diſtance betweene the houres of 6 and 9 in the equator, it ſhall repreſent the axis of the world, and be truly placed for the caſting of the ſhadow vpon the houre-lines in a meridian plane.

CHAP.

CHAP. IIII.

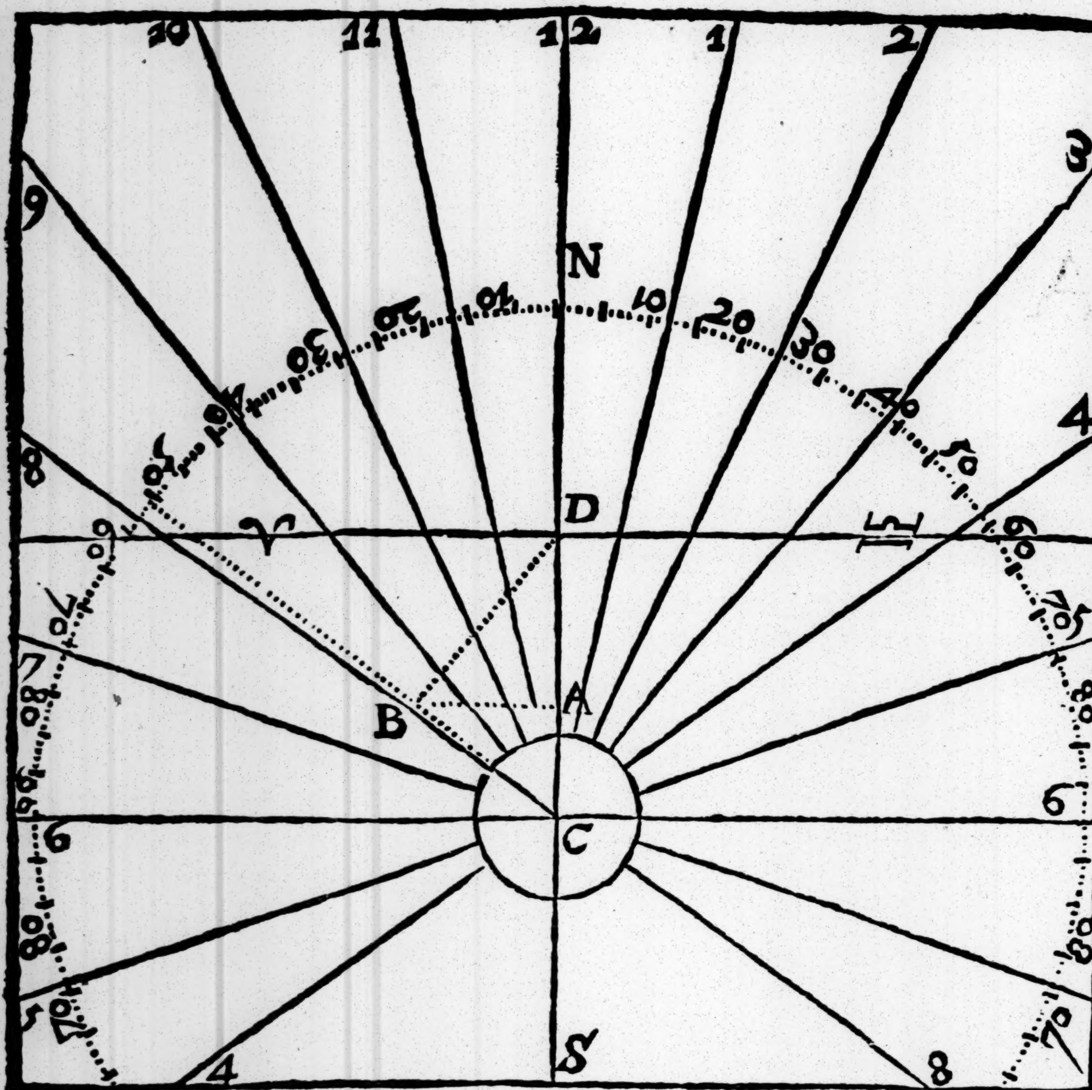
To draw the houre-lines in an horizontall plane.

AN horizontall plane is that which is parallell to the horizon, here represented by the outward circle *E S W N*, in which the diameter *S N* drawne from the South to the North, may go both for the meridian line and the meridian circle, *Z* for the zenith, *P* for the pole of the world, and the circles drawne through *P* for the houre-circles of 1.2.3.4.&c. as they are nūbred from the meridian. These houre-circles considered with the meridian & the horizon, do make diuers triangles, *PN* 1, *PN* 2, *PN* 3, in which we haue knowne first the right angle at *N*, the North intersection of the meridian and the horizon; secondly the side *PN*, the arke of the meridian between the pole and the horizon, which is alwayes equall to the latitude of the place; thirdly the angles at the pole, made by the meridian and the houre-circles, the angle *N P* 1 being 15 *gr*. *N P* 2 30 *gr*. each houre 15 *gr*. more then other, each halfe houre 7 *gr*. 30 *m*. each quarter 3 *gr*. 45 *m*. And these three being known, we may finde the arks of the horizon between the meridian and the houre-circles *N* 1, *N* 2, *N* 3, &c. For

As the sine of 90 *gr*.
is to the sine of the latitude:
So the tangent of the houre
to the tangent of the houre-line from the meridian.

Ho.	Ang. Po Gr.	M.	Arc. Pla Gr.	M.
12	0	0	0	0
	3	45	2	56
	7	30	5	52
	11	15	8	51
1	15	0	11	50
	18	45	14	52
	22	30	17	57
	26	15	21	6
2	30	0	24	20
	33	45	27	35
	37	30	31	0
	41	15	34	28
3	45	0	38	3
	48	45	41	45
	52	30	45	34
	56	15	49	30
4	60	0	53	35
	63	45	57	47
	67	30	62	6
	71	15	66	33
5	75	0	71	6
	78	45	75	45
	82	30	80	25
	86	15	85	13
6	90	0	90	0

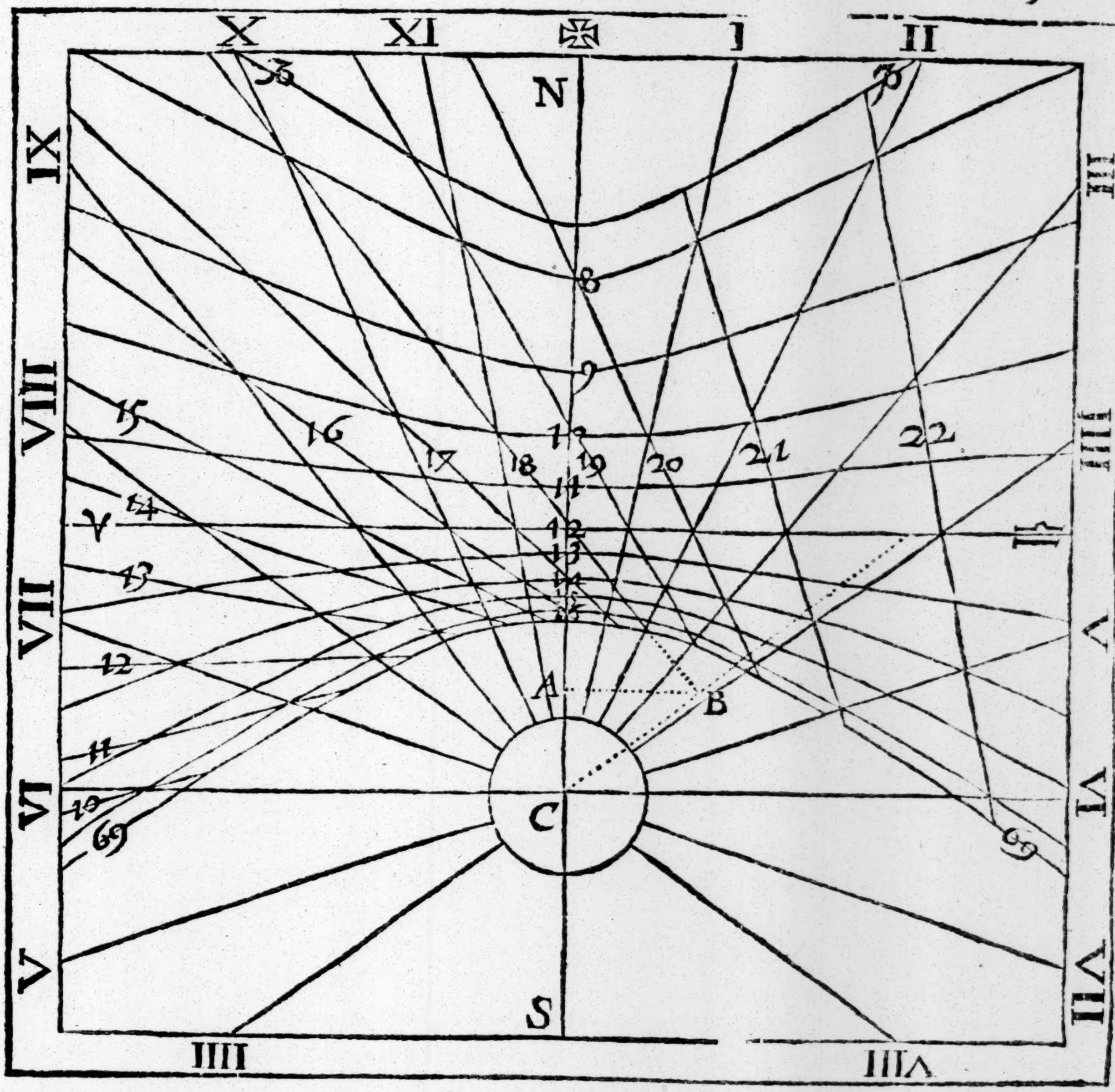
Extend



Extend the compasses from the sine of *90 gr.* to the sine of the latitude, so the same extent shall reach from the tangent of the houre, to the tangent of the houre-line from the meridian. Thus the latitude being 51 *gr.* 30 *m.* I extend the compasses from the sine of *90 gr.* to the sine of 51 *gr.* 30 *m.* & find the same extent to reach from the tangent of 3 *gr.* 45 *m.* vnto the tangent of 2 *gr.* 56 *m.* for the distance of the first quarter from the meridian; and from the tangent of 7 *gr.* 30 *m.* vnto the tangent of 5 *gr.* 52 *m.* for the halfe houre; and from the tangent of 11 *gr.* 15 *m.* to the tangent of 8 *gr.* 51 *m.* for the third quarter; and from the tangent of 15 *gr.* 0 *m.* vnto 11 *gr.* 50 *m.* for the first houre: and so in the rest.

Only when I come to set one foote of the compasses to

48 *gr.*



48 *gr*.45 *m*. for the finding of a quarter past 3, the other foote will fall out of the line, and then I may either take out so much as is out of the line beyond 45 *gr*. and turne it backe into the line, and it will reach from 45 *gr*. to 41 *gr*.45 *m*: or I may vse crosse worke, extending the compasses from the sine of 90 *gr*. to the tangent of 48 *gr*.45 *m*. so the same extent will reach from the sine of 51 *gr*.30 *m*. to the tangent of 41 *gr*. 45 *m*. And such is the distance of the line of 3 ho.¼ from the meridian, as in this table of the Arks of the plane.

This done, I come to the Plane, and there according as the lines do fall in the fundamentall diagram,

1 I draw a right line *S N* seruing for the meridian, the

houre of 12 and the subſtylar.

2 In this meridian I make choice of a center at *C*, and there deſcribe an occult circle repreſenting the horizon.

3 I find a chord of 11 *gr.* 50 *m.* and inſcribe it into this circle on either ſide of the meridian for the houres of 11 & 1; in like maner a chord of 24 *gr.* 20 *m.* for the houres of 10 and 2; and a chord of 38 *gr.* 3 *m.* for the houres of 9 and 3; and ſo for the reſt of the houres, their halues and quarters.

4 I draw right lines through the center and the termes of theſe chords, and theſe lines ſo drawne are the houre-lines required.

Laſtly I ſet vp the ſtyle ouer the meridian, ſo as it may cut the plane in the center, and there make an angle with the meridian equall to the latitude of the place, ſo it ſhall repreſent the axis of the world, and be truly placed for caſting of the ſhadow vpon the houre-lines in an horizontall plane.

CHAP. V.

To draw the houre-lines in a verticall plane.

A Verticall plane is that which is parallel to the prime verticall circle here repreſented by *E Z W*. It hath two faces, one to the North, the other to the South; in each of them the ſubſtylar will be the ſame with the meridian line, and the angle of the ſtyle aboue the plane will be equall to *Z P* the complement of the latitude.

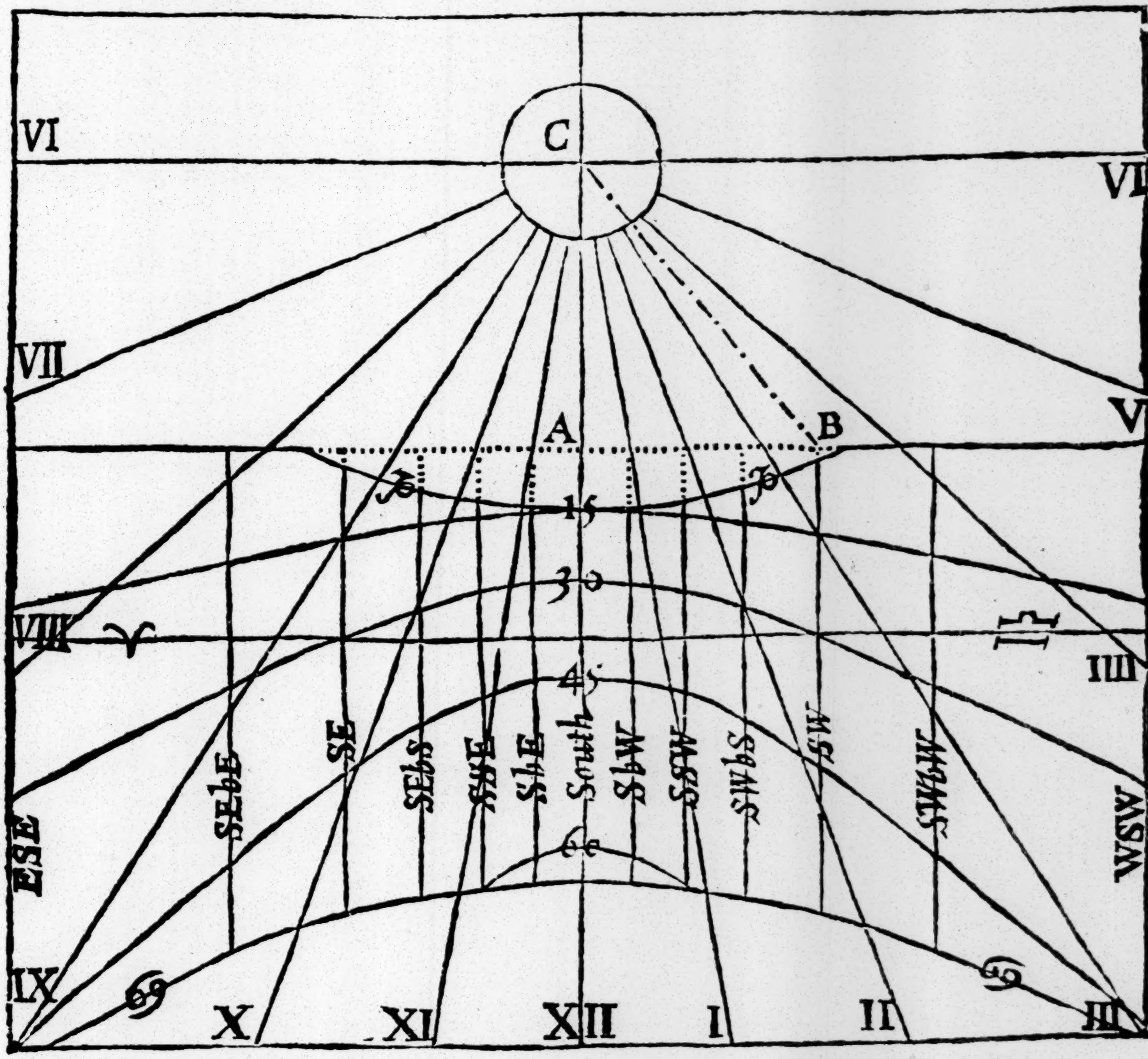
The triangles here conſidered are made by the verticall, the meridian, and the houre-circles, in which we know the ſide *Z P*, the angles at the pole, and the right angle at the zenith, and therefore may find the arks of the verticall, between the meridian and the houre-circles after this maner:

As the ſine of 90 *gr.*
  is to the coſine of the latitude:
So the tangent of the houre
  to the tangent of the houre-line from the meridian.

Extend

Extend the compaſſes from the ſine of *90 gr.* to the ſine of the complement of the latitude, ſo the ſame extent ſhall reach from the tangent of the houre, to the tangent of the houre-line from the meridian.

Thus in the latitude of *51 gr.30 m.* I extend the compaſſes from the ſine of *90 gr.* to the ſine of *38 gr.30 m.* and find the ſame extent to reach from the tangent of *15 gr.* to the tangent of *9 gr.28 m* for the diſtance of the firſt houre from the meridian: and from the tangent of *75 gr.* vnto the tangent of *66 gr.42 m.* for the fift houre: and ſo in the reſt as in the Table following.



Theſe arks being knowne, I may come to the plane, and there by help of a thread and plummet draw a verticall line

seruing both for the meridian and the houre of 12, and the substylar; then may I draw an occult verticall circle, and therein inscribe the chords of those former arks, and draw the houre-lines, and set vp the style, as before in the horizontall plane.

If it be the South face of the plane, the center will be vpward, and the style must point downward; if the North face, the center must be in the lower part of the meridian line, and the style-point vpward in all such places as are to the Northward of the equinoctiall line, as it may appeare by considering how the lines do fall in the fundamentall Diagram.

Ho.	Ang. Po Gr.	Ang. Po M.	Arc. Pla Gr.	Arc. Pla M.
12	0	0	0	0
	3	45	2	20
	7	30	4	41
	11	15	7	3
1	15	0	9	28
	18	45	11	56
	22	30	14	27
	26	15	17	4
2	30	0	19	46
	33	45	22	35
	37	30	25	32
	41	15	28	38
3	45	0	31	54
	48	45	35	22
	52	30	39	3
	56	15	42	58
4	60	0	47	9
	63	45	51	36
	67	30	56	20
	71	15	61	23
5	75	0	66	42
	78	45	72	17
	82	30	78	3
	86	15	84	0
6	90	0	90	0

CHAP. VI.

To draw the houre-lines in a verticall inclining plane.

All those Planes that haue their horizontall line lying East and West, are in that respect said to be verticall; if they be also vpright and passe through the zenith, they are direct verticals; if they incline to the pole they are direct polars: if to the equinoctiall, they are properly called equinoctiall planes, and are described before: if to none of these three points, they are then called by the generall name of inclining verticals.

These may incline either to the North part of the horizon, or to the South; and each of them hath two faces, one to the zenith, the other to the nadir, in which we are first to cōsider the height of the pole aboue the plane, by comparing the incli-

inclination of the plane to the horizon, with the latitude of the place.

As in our latitude of 51 *gr.* 30 *m.* if the inclination of the plane *E I W* shall be 13 *gr.* Northward, that is, if *I N* the ark of the meridian between the plane and the North part of the horizon shall be 13 *gr.* we may take these 13 *gr.* out of *P N* 51 *gr.* 30 *m* the eleuation of the pole aboue the horizon, and there wil remain *P I* 38 *gr.* 30 *m.* for the eleuatiõ of the North pole aboue the vpper face of the plane, and therefore 38 *gr.* 30 *m.* for the height of the South pole aboue the lower face of the plane.

Or if the inclination of the plane shall be found to be 62 *gr.* to the Southward, we may number them in the meridian from *S* the Southpart of the horizon vnto *L*, and there draw the arke *E L W* representing this plane; so the arke of the meridian *P L* shall giue the height of the North pole aboue the vpper face of this plane to be 66 *gr.* 30 *m.* and therefore the height of the South pole aboue the lower face of the plane is also 66 *gr.* 30 *m.*

In like maner if the inclination of the plane *E Y W* shall be 15 *gr.* Southward, that is, if *S Y* the arke of the meridian between the South part of the horizon and the plane, shall be 15 *gr.* The height of the North pole aboue the vpper face of the plane, and the height of the South pole aboue the lower face of the plane, will be also found to be 66 *gr.* 30 *m.*

But if the plane shall fall betweene the zenith and the North pole, then will the North pole be eleuated aboue the lower face, and the South pole aboue the vpward face of the plane, as may appeare by the proiection of the sphere in the fundamentall Diagram.

Then in the triangles made by the plane, the meridian, and the houre-circles, we haue the side which is the height of the pole aboue the plane, together with the angles at the pole, and the right angle at the intersection of the meridian with the plane, by which we may find the arks of the plane betweene the meridian and the houre-circles, after this maner:

As the sine of 90 *gr.*
is to the sine of the pole aboue the plane:
So the tangent of the houre
to the tangent of the houre-line from the meridian.

Thus in the former example, where *PI* the height of the pole aboue the plane was found to be 38 *gr.* 30 *m.* if you shall extend the compasses from the sine of 90 *gr.* to the sine of 38 *gr.* 30 *m.* the same extent wil reach from the tangent of 15 *gr.* vnto the tangent of 9 *gr.* 28 *m.* for the distance of the first houre from the meridian, and from 30 *gr.* vnto 19 *gr.* 46 *m.* for the second houre, and so forward as in the direct vertical.

And for the two last examples, you may extend the compasses from the sine of 90 *gr.* vnto the sine of 66 *gr.* 30 *m*: so the same extent shal reach in the line of tangents from 15 *gr.* vnto 13 *gr.* 48 *m.* for the first houre, from 75 *gr.* vnto 73 *gr.* 43 *m.* for the fift houre, from 30 *gr.* vnto 27 *gr.* 54 *m.* for the second houre, from 60 *gr.* vnto 57 *gr.* 48 *m.* for the fourth houre, and from 45 *gr.* vnto 42 *gr.* 31 *m.* for the third houre from the meridian.

These arks being knowne, you may first draw the horizontall line, and crosse it in the middle with a perpendicular that may serue both for the meridian and the houre of 12, and the substylar; then knowing which pole is eleuated aboue the plane, you may accordingly make choice of a fit point in the meridian for the center of your houre-lines, and thence describe an occult arke of a circle, inscribe the chords of those former arks, and draw the houre lines, and set vp the style, as I shewed before in the horizontall plane.

CHAP. VII.
To draw the houre-lines in an verticall declining Plane.

ALl vpright planes whereon a man may draw a verticall line, are in this respect said to be verticall; if they shall also

also stand directly East and West, they are direct verticals; if directly North and South, they are properly called meridian planes, and are described before: if they behold none of these foure principall parts of the world, but shall stand between the prime verticall and the meridian, they are then called by the generall name of declining verticals.

These haue two faces, one to the South, the other to the Northward, which may be distinguished in these Northerne parts of the world after this maner. If the Sunne coming to the meridian shall shine vpon the plane, it is the South face; if not, it is the North face of that plane. Againe, if the Sunne shall shine vpon the plane at high noone, and yet longer in the forenoone then in the afternoon, it is the Southeast face; if longer in the afternoone then in the forenoone, it is the Southwest face of the plane. But how much the declination cometh to, is best found as before.

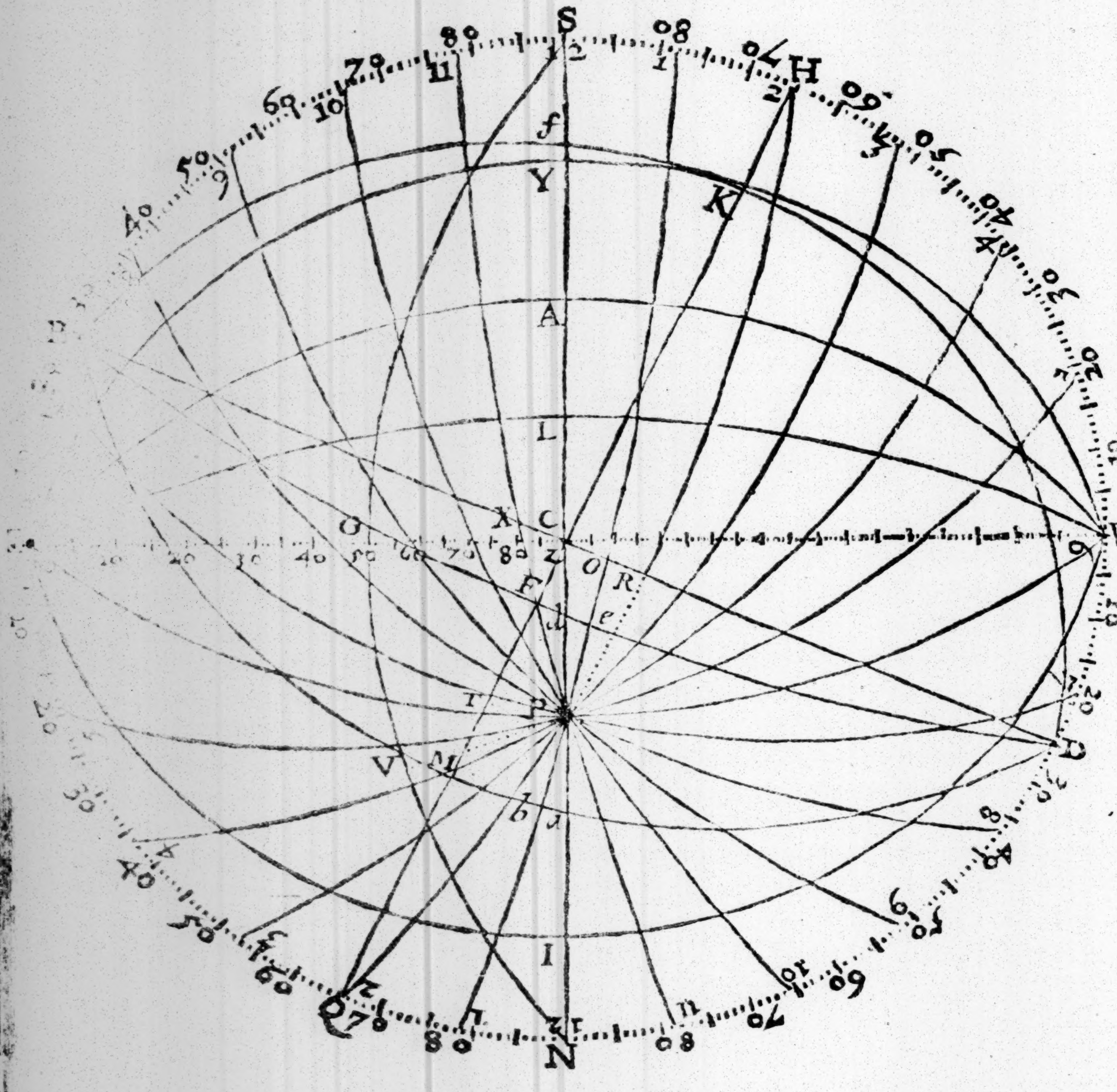
When the declination is found, there be foure things more to be considered before we can come to the drawing of the houre-lines, and all foure represented in the fundamentall Diagram.

1 *The meridian of the plane and his inclination to the meridian of the place.*

Let the arke *E Z W* represent the prime verticall, and *B Z D* a declining verticall, according to the angle of declination *E Z B*, the meridian of the place is represented by *P Z S*, crossing the verticall *E Z W* at right angles at the zenith in the point *Z*: but the proper meridian of the plane wil be *PR*, which is a perpendicular let downe from the pole vnto the declining verticall, and crossing it with right angles in the point *R*, so the angle *R P Z* shall shew the inclination of the two meridians, and may thus be found.

In the triangle *P R Z* we know the angle at *R* to be a right angle, and the angle at *Z*, for it is the complement of the declination, and the base *PZ*, for it is the complement of the latitude. And therefore

As



As the sine of the latitude
is to the sine of 90 gr.
So the tangent of the declination
to the tangent of the inclination required.

2 *The height of the style aboue the plane.*

This is here represented by the perpendicular arke *P R*, and may be found by that which we haue knowne in the former triangle *P R Z*. For

As the ſine of *90 gr.*
to the coſine of the latitude:
So the coſine of the declination
to the ſine of the height of the ſtyle.

Or if you pleaſe to make vſe, of the angle of the inclination of the two meridians, the proportion will hold.

As the ſine of *90 gr.*
to the coſine of the inclination of meridians:
So the cotangent of the latitude
to the tangent of the height of the ſtyle.

3 *The diſtance of the ſubſtylar from the meridian.*

This is here repreſented by the arke *Z R*, and may be found by that which we haue knowne in the former triangle *PRZ*.

As the ſine of *90 gr.*
to the ſine of the declination:
So the cotangent of the latitude
to the tangent of the ſubſtylar from the meridian.

4 *The diſtance of each houre-line from the ſubſtylar.*

The diſtances of the houre-lines from the ſubſtylar, are here repreſented by thoſe arks of the declining verticall belonging to the plane, which are intercepted betweene the proper meridian of the plane and the houre-circles.

To this purpoſe we haue diuers triangles made by the declining plane, together with his proper meridian and the houre-circles. In theſe we haue knowne, firſt the right angle at the interſection of the proper meridian with ẏ plane; then the ſide which is the height of the pole aboue the plane; and thirdly the angles at the pole. For knowing the angle of inclination betweene the meridian of the plane and the meridian of the place, which is alwayes the houre of 12, we may finde the angle betweene the meridian of the plane and the houre of 1, by allowing in 15 *gr.* and the angle betweene

the meridian of the plane and the houre of 2, by allowing in 30*gr.* and so for the rest, which being knowne, we may find the arks of the plane from the substylar to the houre-circles, in this maner.

As the sine of 90 *gr.*
to the sine of the height of the pole aboue the plane:
So the tangent of the houre from the proper meridian,
to the tangent of the houre-line from the substylar.

Thus in our latitude of 51 *gr.* 30 *m.* if the declination of an vpright plane shall be found to be 24 *gr.* 20 *m.* from the prime verticall, the one face open to the Southwest, the other to the Northwest, I may number these 24 *gr.* 20 *m.* in the horizon of the fundamentall Diagram, from *E* vnto *B*, according to the situation of the plane, and there draw the verticall *B Z D*, which shall represent the plane proposed.

Then taking the compasses into my hand,

1 I may extend them from the sine of the latitude 51 *gr.* 30 *m.* vnto the sine of 90 *gr.* the same extent will reach in the line of tangents from 24 *gr.* 20 *m.* the declination giuen, to about 30 *gr.* and such is *Z P R* the angle of inclination between the meridiã of the place & the meridian of the plane; and therefore the meridian of the plane will here fall vpon the circle of the second houre frõ the meridian of the place, (as it may also appeare by opening the compasses to the nearest extent, between the pole and the plane) and there I place the letter *R* to make this rectangle triangle *P R Z*.

2 I extend the compasses from the sine of 90 *gr.* vnto the sine of 38 *gr.* 30 *m.* the complement of the latitude, and the same extent will reach from the sine of 65 *gr.* 40 *m.* the complement of the declination, vnto the sine of 34 *gr.* 33 *m.*

Or I may extend them from the sine of 90 *gr.* vnto the sine of 60 *gr.* the complement of the inclination of the meridians, and the same extent wil reach from the tangent of 38 *gr.* 30 *m.* the complement of the latitude, vnto the tangent of 34 *gr.* 33 *m.* and such is the arke *P R*, the height of the pole aboue the plane.

3 I may extend the compasses from the sine of 90 *gr.* vnto the sine of 24 *gr.* 20 *m.* the declination giuen, and the same extent will reach from the tangent of 38 *gr.* 30 *m.* the complement of the latitude, vnto the tangent of 18 *gr.* 8 *m.* and such is the arke *Z R*, the distance of the substylar from the meridian.

4 That I may finde the distance of each houre-line from the substylar, I consider the angle of inclination of the meridians *R P Z*, and there see how that *P Z* the meridian of the place, which is the houre of 12, being 30 *gr.* distance from *PR* the meridian of the plane, and that one face of the plane being open to the Southwest, and the other to the Northeast, this meridian of the plane falleth to be the same with the houre of 2, (otherwise with the houre of 10:) therefore allowing 15 *gr.* for an houre, the houre of 1, *R P O* will be 15 *gr.* and *R P X* the houre of 11, 45 *gr.* distant from *PR* the proper meridian of the plane: and so I gather the inclination of the rest of the houre-circles toward this meridian, according to their angles at the pole, as in this Table.

Ho.	Ang. Po. Gr.	M.	Ar. Pla. Gr.	M.
8	90	0	90	0
9	75	0	64	42
10	60	0	44	30
11	45	0	29	33
12	30	0	18	8
1	15	0	8	38
2	*Merid*		*substyl*	
3	15	0	8	38
4	30	0	18	8
5	45	0	29	33
6	60	0	44	30
7	75	0	64	42
8	90	0	90	0

Then taking my compasses in my hand, I extend them from the sine of 90 *gr.* vnto the sine of 34 *gr.* 33 *m.* the height of the pole aboue the plane, and finde them to reach in the line of tangents from 15 *gr.* the inclination of the houre of 1, to 8 *gr.* 38 *m.* for the arke of 1, from the substylar, and from 30 *gr.* vnto 18 *gr.* 8 *m.* for the houre of 12, agreeable to the third *Prop.* and from 45 *gr.* vnto 29 *gr.* 33 *m.* for the houre of 11, and so the rest, which I also set downe in a Table.

These arks being thus found, wil serue for the drawing of the houre-lines, both on the Southwest face, and the Northwest face of the plane.

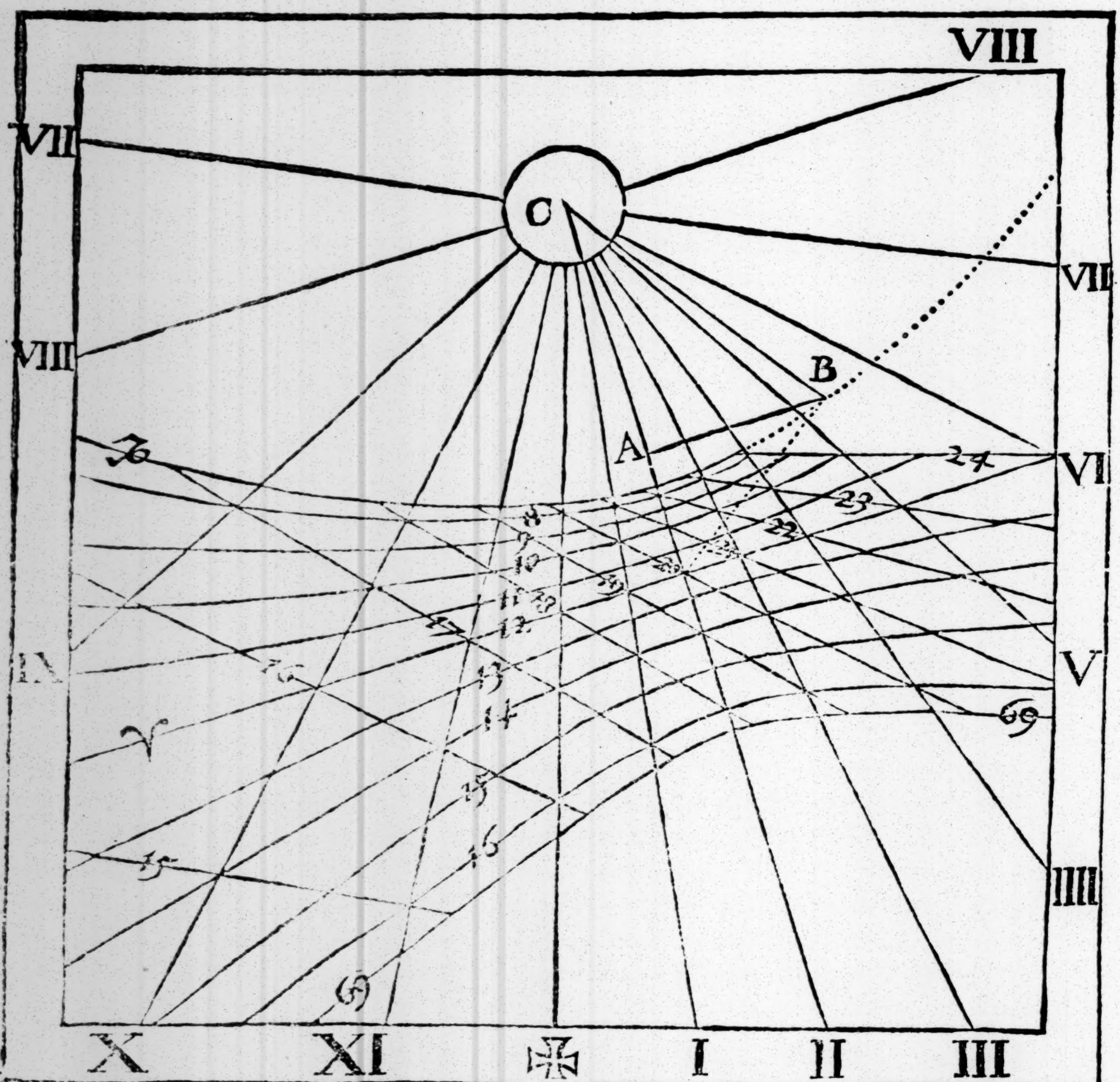
For coming to the plane,

1 By the help of a thread and plummet I draw a verticall

line, ſeruing both for the meridian of the place and the houre of 12.

2 In this meridian line I make choice of a center at *C*, in the vpper part of the line, if it be the South face, as here we ſuppoſe it, that the ſtyle may haue roome to point downward; but in the lower part of the line, if it be the North face of the plane; for there the ſtyle muſt point vpward: and vpon this center I deſcribe an occult circle, repreſenting the declining verticall belonging to the plane.

3 I find a chord of 18 *gr.* 8 *m.* the diſtance of the ſubſtylar from the meridian of the place, and inſcribe it into this cir-



cle,from the meridian vnto *A* toward the right hand, because in this example the meridian of the plane falls among the houres after noone, (for otherwise it must haue been inscribed toward the left hand) and there I draw the line *C A* seruing for the substylar.

4 According to the Table of the arkes of the plane from the substylar, I find a chord of 8 *gr.* 38 *m.* and inscribe it into this circle, from the substylar toward the meridian, for the houre of 1. In like maner a chord of 29 *gr.* 23 *m.* for the houre of 11, and a chord of 44 *gr.* 30 *m.* for the houre of 10, and so for the rest of the houres, their halues and quarters.

5 I draw right lines through the center and the termes of these chords, and these lines so drawne are the houre-lines required.

Lastly, I set vp the style ouer the substylar, so as it may cut the plane in the center, and there make an angle with the substylar of 34 *gr.* 33 *m.* according to the height of the pole aboue the plane; so it shall represent the axis of the world, and be truly placed for casting of the shadow vpon the houre-lines in this declining plane.

A second example.

After the like maner if in our latitude an vpright plane shall decline 85 *gr.* from the prime verticall, the one face of it being open to the Northwest, and the other to the South-east, we may in some sort represent it by the verticall *QZH*, and then working as before.

1 The angle *Z P T*, the inclination of the two meridians will be found to be 86 *gr.* 5 *m.* so that *P T* the meridian of this plane, will here fall between the houre-circles of 6 and 7 from the meridian.

2 The arke *P T* the height of the pole aboue the plane will be onely 3 *gr.* 6 *m.*

3 The arke *Z T* the distance of the substylar from the meridian 38 *gr.* 23 *m.*

4 The Table of the angles at the pole will be also gathered, by comparing the meridian of the plane with the rest of the houre-circles. For the angle *TPZ* betweene *PT* the meridian of the plane, *PZ* the meridian of the place, and the houre of 12, being 86 *gr.* 5 *m.* allowing 15 *gr.* for an houre, the houre of $11\frac{1}{2}$ wil be 78 *gr.* 35 *m.* and the houre of 11 71 *gr.* 5 *m.* distant from the meridian of the plane; & so the rest of the houres, as in the second columne of this Table.

Hor.	Ang. Po		Ar. Pla.		C F		C G	
	Gr.	M.	Gr.	M	In.	Par.	In.	Par.
12	86	5	38	23	91	08	79	21
	78	35	15	3	30	92	26	89
11	71	5	9	6	18	42	16	02
	63	35	6	13	12	52	10	89
10	56	5	4	36	9	25	8	05
9	41	5	2	42	5	43	4	72
8	26	5	1	31	3	05	2	65
7	11	5	0	36	1	20	1	05
	Merid.		*Substyl*		0	0	0	0
6	3	55	0	13	0	44	0	38
5	18	55	1	4	2	15	1	86
4	33	55	2	5	4	18	3	64
3	48	55	3	33	7	13	6	20
2	63	55	6	20	12	77	11	10
	71	25	9	10	18	56	16	14
1	78	55	15	28	31	82	27	67
	86	25	40	55	99	67	86	68

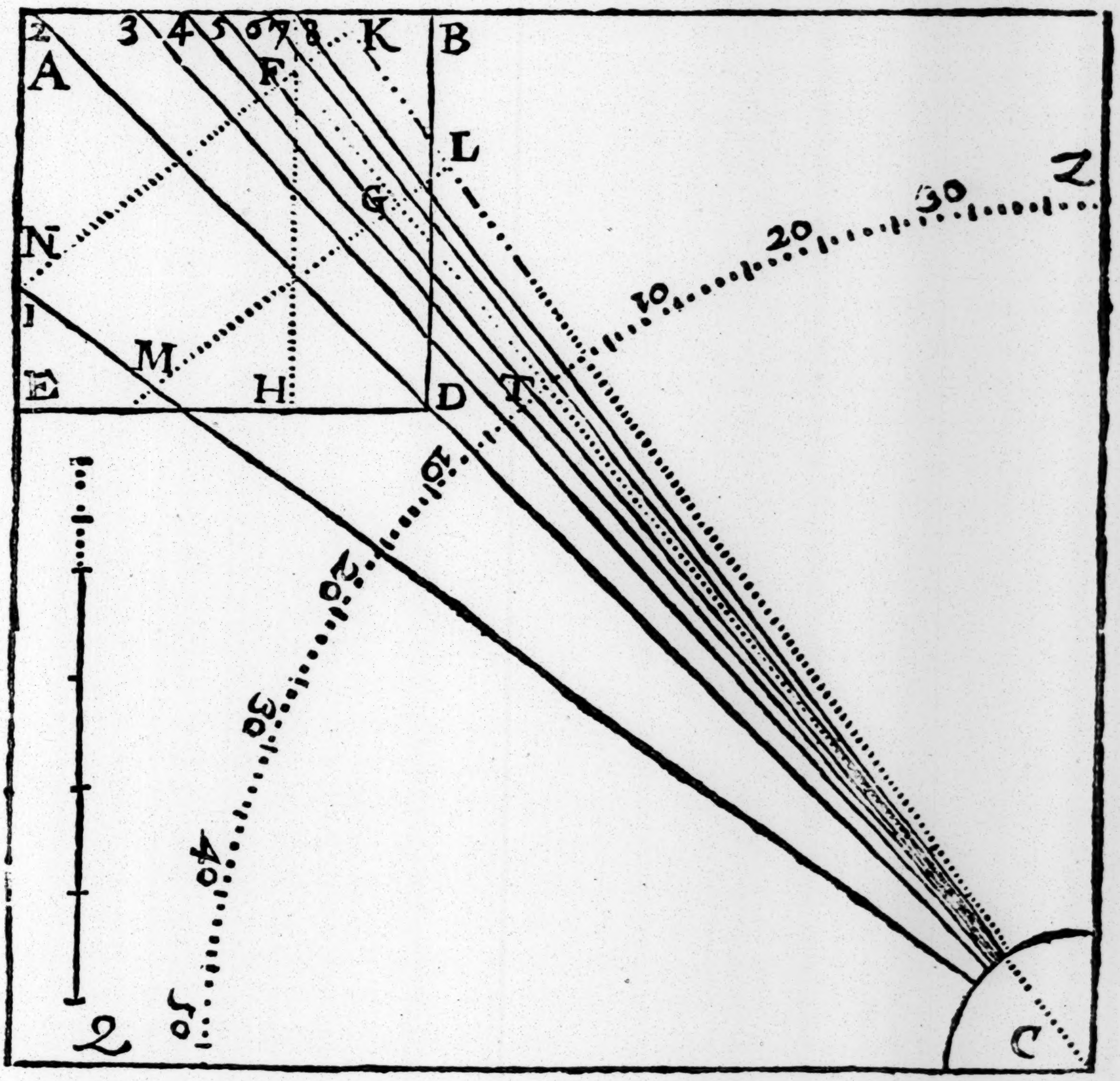
Then hauing the height of the pole aboue the plane, and these angles at the pole; the arkes of the plane, betweene the substylar and the houre-circles, will be found as in the third columne.

These arks being found, will serue for the drawing of the houre-lines on either face of this plane.

1 By the help of a thread and plummet I draw *ZC* a verticall plane, seruing both for the meridian of the place and the houre of 12.

2 In this meridian line I make choice of a center in the vpper part of the line, if it had been the Southerne face of the plane, but here in *C* the lower part of the line, because we supposed it to be the Northwest face of the plane, and the style must point vpward; and vpon this center I describe an occult circle representing the declining verticall belonging to this plane.

3 I finde a chord of 38 *gr.* 23 *m.* the distance of the substylar



ſtylar from the meridian of the place, and inſcribe it into this circle, from *Z* in the meridian, vnto *T* toward the left hand, acording as the proper meridian *PT* falls in the fundamentall Diagram; and here I draw the line *CT* ſeruing for the ſubſtylar.

4 The ſubſtylar being drawne, I may inſcribe the chords of the arks of the plane from the ſubſtylar, and draw the houre-lines, and ſet vp the ſtyle as in the former plane.

Or the arks of the plane from the ſubſtylar being found as before, we may draw the houre-lines vpon the plane otherwiſe then by chords. For hauing drawne the houre-lines as in the laſt figure, vpon paper or paiſt-boord, we ſhall find

the

the most part of them, in this and such like planes that haue greater declination, to fall so close together, that they can hardly be discerned: wherefore to draw them at large to the best aduantage of the plane, I leaue out the center, and draw them by tangents, as in the polar plane.

1 I consider the length and bredth of the plane whereon I am to draw the houre-lines, which I suppose to be a square, whose side is 36 inches, and find that the little square *A B D E* wil contain both the substylar and all those houre-lines which are required in the great square *A Z C Q.*

2 I draw two parallell lines *F N*, *G M*, crossing the substylar at right angles in the points *F* & *G*, so as they may best crosse all the houre-lines, and yet the one be distant from the other as far as the plane will giue me leaue; and I find by the sight of the figure that if *AB* the side of the lesser square shall be 36 inches, the line *C F* will be about 115 inches, and the line *C G* about 100 inches, and therefore *FG* 15 inches. Againe, that the point *F* will fall about 6 inches below the vpper horizontall side *A B*, and about 12 inches from the next verticall side *B D*; for I need not here stand vpon parts.

3 Because these two parallell lines are tangent lines in respect of circles drawne vpon the semidiameters *C F*, *C G*, and such tangents as belong to the arkes of the plane, betweene the substylar and the houre-lines, the proportion will hold,

As the tangent of 45 *gr.*
to the tangent of the arke of the plane:
So the length of the semidiameter
to the length of the tangent line.

As for example, the arke of the plane betweene the substylar and the houre of 1, is 15 *gr.* 28 *m.* in the former Table, the semidiameter *C F* 115 inches, and the semidiameter *C G* 100 inches: wherefore I extend the compasses from the tangent of 45 *gr.* vnto the tangent of 15 *gr.* 28 *m.* the same extent will reach from 115 in the line of numbers vnto 31,82, which shewes the length of the tangent line betweene *F* in the substylar and the houre-line of 1, to be 31 inches, 82 *cent.*

or

or parts of 100. Againe, the same extent will reach from 100 vnto 27, 67; and such is the length of the lesser tangent from *G* to the houre of 1.

The like reason holds for the length of the other tangents from the substylar to the rest of the houres, as in the Table; as also for the height of the style aboue these tangent lines; and so the angle of the style aboue the plane being 3 *gr.* 6 *m.* the height *FK* will be found to be 6 inches 23 *cent.* and the height *GL* 5 inches 42 *cent.*

Where the Reader may obserue, that if the extent from the tangent of 45 *gr.* to the tangent of 3 *gr.* 6 *m.* or to 115 in the line of numbers, be too large for his compasses, he may vse the tangent of 5 *gr.* 43 *m.* in stead of the tangent of 45 *gr.* as I noted before *Pag.* 100.

4 Hauing found these lengths and heights, and set them downe in a Table, I come to the plane here resembled by the lesser square *A B D E*, where I begin with an occult verticall *F H*, about 12 inches from the side *B D*, and vpon the center *F*, about 6 inches below the side *A B* describe an occult arke of a circle.

5 Into this arke I first inscribe a chord of 38 *gr.* 23 *m.* the distance of the substylar from the meridian, to make the angle *H F G* equall to the *Z C T*; so the line *F G* shall be the substylar: and then another chord of 51 *gr.* 37 *m.* the complement of this distance, to make vp the right angle *G F N*; so the line *F N* shall be the greater of the two tangent lines before mentioned.

6 I set off 15 inches from *F* vnto *G*, toward the center, and through *G* draw the lesser tangent line *G M* parallell to the former.

7 These two occult tangent lines being thus drawne, I looke vnto the former Table for the houre of 1, and there finde the arke of the plane betweene the substylar and the houre of 1, to be 15 *gr.* 28 *m.* and the length belonging to it in the greater tangent line to be 31 inches 82 *cent.* in the lesser tangent line 27 inches 67 *cent:* wherefore I take out 31 inches 82 parts, and pricke them downe in the greater

tangent from *F* to *N*, and then 27 inches 67 parts, and prick them downe in the lesser tangent from *G* to *M*, and draw the *MN* for the houre of 1, which if it were produced would crosse the substylar *FG* in the center *C*, and there make the angle *FCN* 15 *gr.* 28 *m*. The like reason holdeth for the drawing of all the rest of the houre-lines.

Lastly I set vp the style right ouer the substylar, so as the height *FK* may be 6 inches 23 *cent.* and the height *GL* 5 inches 42 *cent.* then shall *KL* represent the axis of the world, and if it were produced would crosse the substylar *FG* in the center *C*, and there make the angle *FCK* to be 3 *gr.* 6 *m.* and so be truly placed for casting of the shadow vpon the houre-lines in this declining plane.

CHAP. VIII.

To draw the houre-lines in a meridian inclining plane.

ALl those planes wherein the horizontall line is the same with the meridian line, are therefore called meridian planes: if they be right to the horizon, they are called by the generall name of meridian planes without farther addition, and are described before: if they leane to the horizon, they are then called meridian incliners.

These may incline either to the East part of the horizon, or to the West, and each of them hath two faces, the vpper toward the zenith, the lower toward the Nadir, wherein knowing the latitude of the place, and the inclination of the plane to the horizon, we are to consider

1. The inclination of the meridian of the plane to the meridian of the place.
2. The height of the pole aboue the plane.
3. The distance of the substylar from the meridian.
4. The distance of each houre-line from the substylar.

And all these foure are represented in the fundamentall Diagram.

Diagram, as in this example.

In our latitude of 51 *gr.* 30 *m.* a meridian plane inclineth Eastward 50 *gr*; these 50 *gr.* I number in the verticall circle from *E* vnto *G*, according to the inclination of the plane, and there draw the arke *S G N* representing the plane proposed. Then I let downe a perpendicular arke *P V* from the pole to the plane, seruing for the meridian of the plane, so haue I a rectangle triangle *P V N*, wherein the base *P N* is the height of the pole aboue the North part of the horizon, and the angle *P N V* the complement of the inclination to the horizon; and these being knowne,

1 I may finde the angle *N P V* of inclination of the two meridians. For

As the cosine of the latitude
is to the sine of 90 *gr.*
So the tangent of inclination to the horizon,
to the tangent of inclination of meridians.

Extend the compasses from the sine of 38 *gr.* 30 *m.* the complement of the latitude, vnto the sine of 90 *gr.* the same extent will reach from the tangent of 50 *gr.* 0 *m.* the inclination of the plane to the horizon, vnto the tangent of 62 *gr.* 25 *m.* and such is the inclination of the meridian of the plane to the meridian of the place; which being resolued into time, doth giue about 4 houres and 10 *m.* from the meridian, for the place of the substylar among the houre-lines.

2 The height of the pole aboue the plane is here represented by the quantitie of the arke of the proper meridian *PV*, betweene the pole and the plane, and may be knowne by that which we haue giuen in the former triangle *P V N*. For

As the sine of 90 *gr.*
to the sine of the latitude:
So the cosine of the inclination to the horizon,
to the sine of the height of the pole aboue the plane.

Extend the compasses from the sine of 90 *gr.* vnto 51 *gr.* 30 *m.* the sine of the latitude, the same extent wil reach from

the sine of 40 *gr.* the complement of the inclination of the plane to the horizon, vnto the sine of 30 *gr.* 12 *m.*

Or as the sine of 90 *gr.*
to the cosine of inclination of meridians:
So the tangent of the latitude
to the tangent of the height of the pole aboue the (plane.

Extend the compasses from the sine of 90 *gr.* vnto the tangent of 51 *gr.* 30 *m.* the latitude of the place, the same extent will reach from the sine of 27 *gr.* 35 *m.* the complement of the inclination of the two meridians, vnto the tangent of 30 *gr.* 12 *m.* And such is *PV* the height of the pole aboue the plane, and such must be the height of the style aboue the substylar.

3 The distance of the substylar from the meridian is here represented by *NV* the arke of the plane betweene the two meridians, and may be found by that which we haue giuen at the first in the former triangle *PVN*. For

As the sine of 90 *gr.*
to the sine of the inclination to the horizon:
So the tangent of the latitude
to the tangent of the substylar from the meridian.

Extend the compasses from the sine of 90 *gr.* vnto the tangent of 51 *gr.* 30 *m.* the latitude of the place, the same extent will reach from the sine of 50 *gr.* the inclination of the plane to the horizon, vnto 43 *gr.* 55 *m.* And such is the arke *NV* the distance of the substylar from the meridian.

4 The distances of the houre-lines from the substylar, are here also represented by those arkes of the plane, which are here intercepted betweene the proper meridian and the houre-circles, and may be found by that which we haue giuen in the triangles made by the plane, with his proper meridian and the houre-circles. For the angle at *V*, betweene the plane and the proper meridian, is well knowne to be a right angle, and the side *PV* is the height of the pole aboue the plane, and the angles at the pole betweene the proper meridian and the houre-circles are easily gathered into a Table.

ble. The angle *VPN* betweene *VP* the proper meridian of the plane, and *PN* the generall meridian of the place being *62 gr. 25 m.* the angle between the proper meridian and the circle of the houre of 11, will be 77 *gr.* 25 *m.* and the angle belonging to the houre of 1, 47 *gr.* 25 *m*, and so the rest of the angles at the pole. Then

Hor.	Ang. Po.		Arc. Pla.	
	Gr.	M.	Gr.	M.
11	77	25	66	4
12	62	25	43	55
1	47	25	28	41
2	32	25	17	43
3	17	25	8	58
4	2	25	1	13
	Merid		*Substyl*	
5	12	35	6	26
6	27	35	14	44
7	42	35	24	48
8	57	35	38	23
9	72	35	58	3
10	87	35	85	12

As the sine of 90 *gr.*
to the sine of the pole aboue ỹ plane:
So the tangent of the angle at the pole,
to the tangent of the houre-line from the substylar.

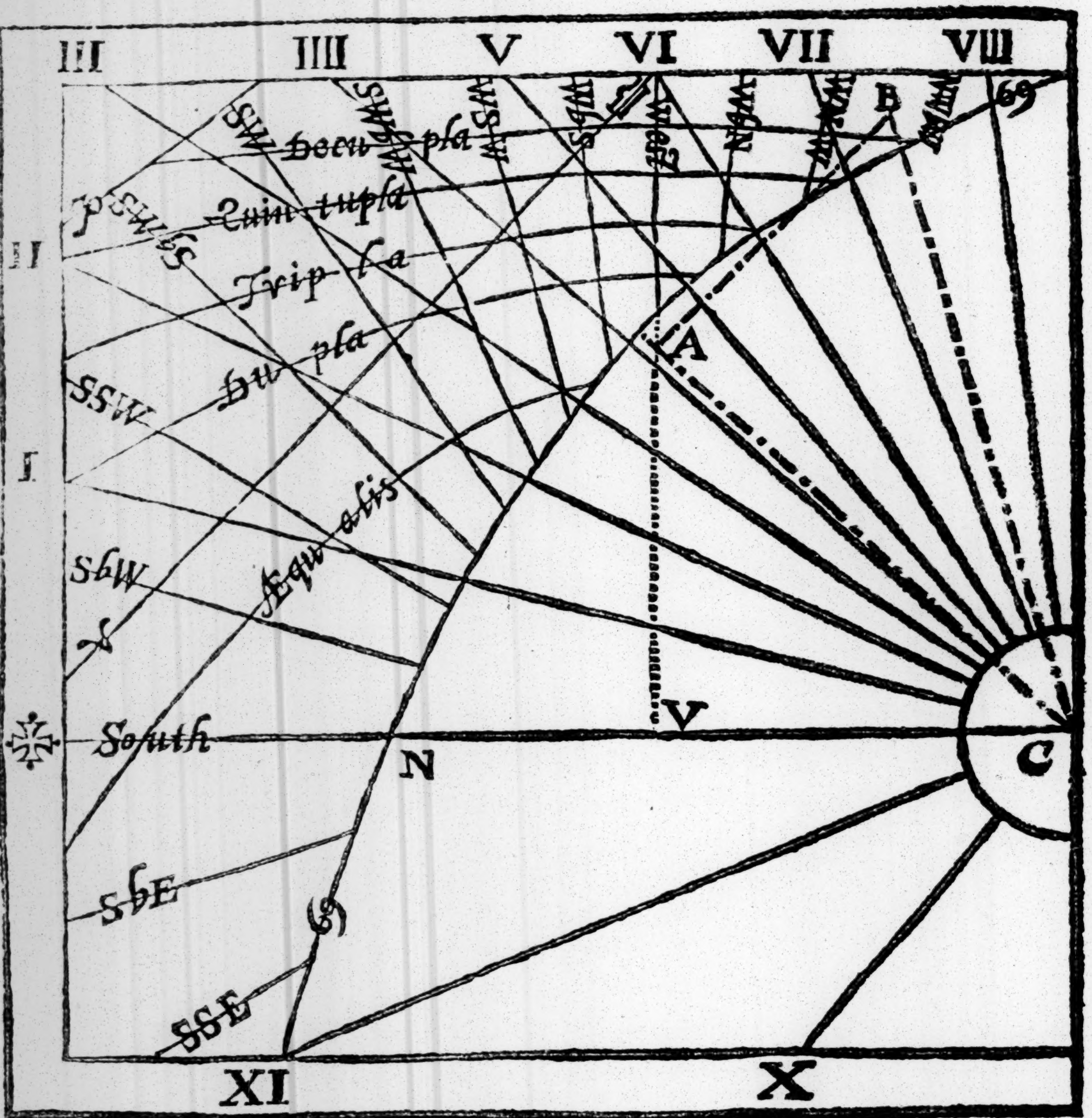
Wherefore I extend the compasses from the sine of 90 *gr.* vnto the sine of 30 *gr.* 12 *m.* the height of the pole aboue the plane, and I finde the same extent to reach in the line of tangents from 77 *gr* 25 *m.* vnto 66 *gr.* 4 *m.* for the distance belonging to the houre of 11; and from the tangent of 62 *gr.* 25 *m.* to 43 *gr.* 55 *m.* for the houre of 12. as when I found the distance of the substylar from the meridian. And so for the rest of the arks of plane betweene the substylar and the houre-circles, as in the Table.

These arks being thus found, wil serue to draw the houre-lines on either side of this plane: but supposing it to be the vpper side,

1 I draw the horizontall line *CN*, seruing for the meridian and houre of 12.

2 In this line I make choice of a center at *C*, and thence describe an occult arke of a circle representing the plane proposed.

3 I find a chord of 43 *gr.* 55 *m.* the distance of the substylar from the meridian, and inscribe it into this circle from *N* vnto *A*, according as I finde the proper meridian *PV* to fall in the fundamental diagram, and there I draw the line *CA* seruing for the substylar.



4 The substylar being drawne, I may inscribe the chords of the arkes of the plane from the substylar, and draw the houre-lines, and set vp the style, as in the former planes.

CHAP. IX.

To draw the houre-lines in a polar declining Plane.

THose planes wherein a line may be drawne parallell to the axis of the world, are called polar planes, because that

that line pointeth vnto the poles,and these planes are always parallell to some one of the houre-circles. If they be parallell to the houre of *6*, they are called direct polar planes; if to the houre of 12, they are called meridian planes; and both these are described before: if to any other of the houre-circles, they are then called by the name of polar declining planes, because of their inclining to the pole, and declining from the verticall.

These kind of planes may be knowne in this sort: First consider the inclination of the plane to the horizon, which in these parts of the world must alwayes be Northward, and more then the latitude of the place. Then find the declination from the verticall. These two being knowne, if the proportion hold,

As the sine of *90 gr.*
to the cosine of the declination:
So the tangent of the inclination
to the tangent of the latitude;

it is then a polar declining plane, otherwise not.

For example, in our latitude of 51 *gr.* 30 *m.* a plane is proposed declining from the verticall 65 *gr.* 40 *m.* and inclining Northward 71 *gr.* 51 *m.* the vpper face being open to the Southeast, and the lower to the Northwest. If I number those 65 *gr.* 40 *m.* in the horizon of the fundamentall diagram from *E* vnto *Q*, and draw the line *H C Q*, it shall represent the horizontall line of the plane; then crossing it at right angles with the plane *B Z D* drawne through the zenith, I number 71 *gr.* 51 *m.* for the inclination from *D* vnto *R*, and there draw the circle *H R Q*, this circle so drawne shall represent the plane proposed; and because it also passeth through the pole, it is therefore a polar plane. But for farther triall I extend the compasses from the sine of 90 *gr.* to the sine of 24 *gr.* 20 *m.* the complement of the declination, and I find the same extent to reach from the tangent of 71 *gr.* 51 *m.* the inclination proposed, vnto the tangent of 51 *gr.* 30 *m.* which is the true latitude of the place, and therefore it is a polar plane.

Here

Here then the style will be parallell to the plane, and the houre-lines parallell one to the other, as in the meridian and direct polar planes. But that we may know how to draw the houre-lines, and where to place the style, we are to consider

1 *The arke of the plane betweene the horizon and the houre-lines.*

In a meridian plane the arke betweene the horizon and the hourelines, is alwayes equall to the latitude of the place; in a direct polar it is an arke of 90 *gr*; in these declining polars it is greater then the latitude, and yet lesse then 90 *gr*. and may be knowne in this maner.

As the sine of 90 *gr*.
  to the cosine of the latitude:
So the sine of the declination
  to the cosine of the arke betweene the horizon and the houre-lines.

Extend the compasses from the sine of 90 *gr*. vnto the sine of 38 *gr*. 30 *m*. the complement of the latitude, the same extent will reach from the sine of 65 *gr*. 40 *m*. the declination proposed, vnto the sine of 34 *gr*. 34 *m*. whose complement 55 *gr*. 26 *m*. the arke of the plane betweene the horizon and the substylar, to which all the houre-lines must be parallell.

2 *The inclination of the meridian of the plane to the meridian of the place.*

The substylar in a direct polar plane is alwayes the same with the houre of 12: in a meridian plane it is the same with the houre-line of 6: in these declining polars it must be placed betweene 12 and 6, according to the inclination of the meridian of the plane to the meridian of the place, which is thus knowne.

As the sine of 90 *gr*.
  to the sine of the latitude:

So

So the tangent of the declination of the plane,
to the tangent of the inclination of meridians.

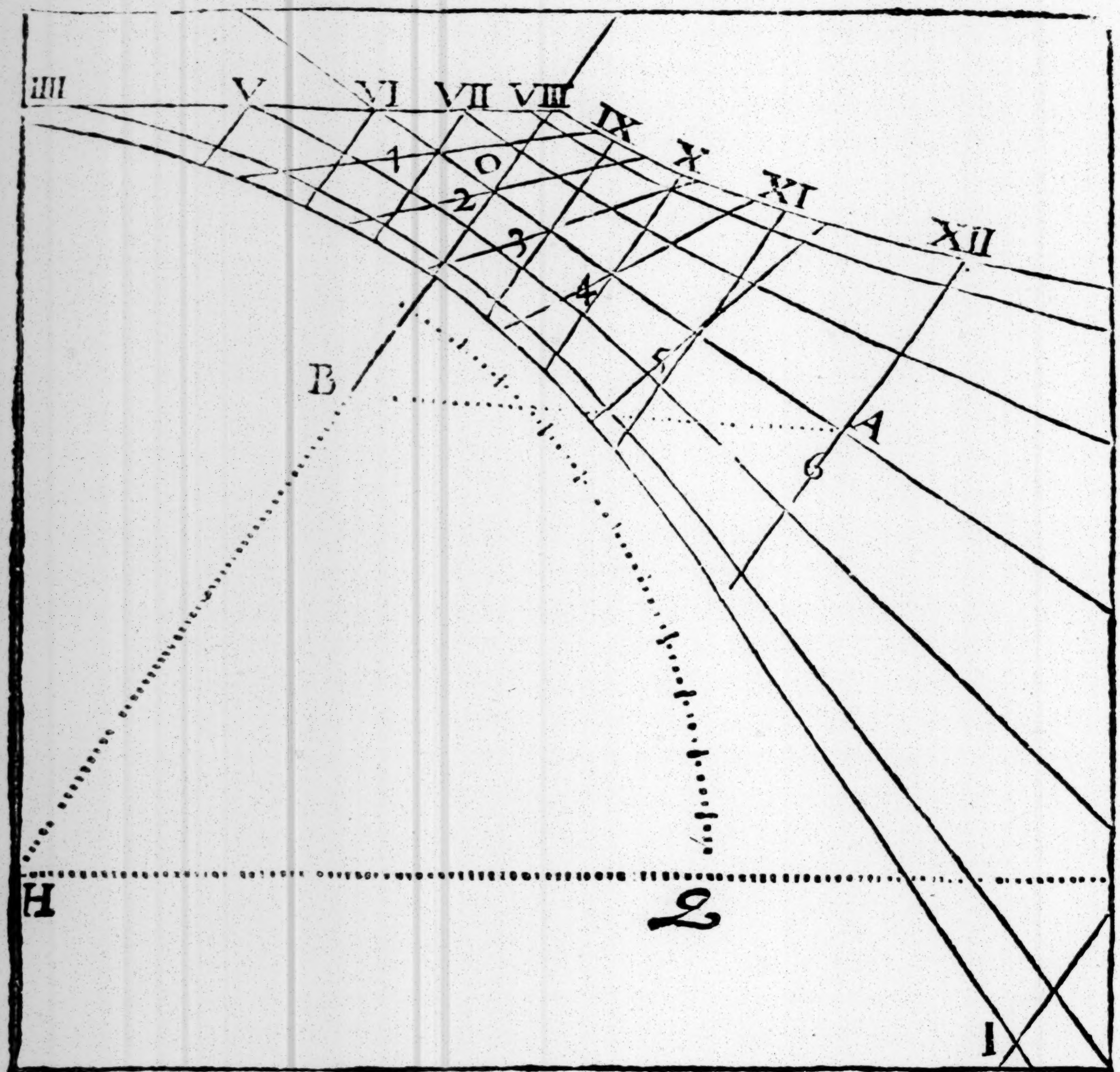
Extend the compasses from the sine of *90 gr.* to the sine of *51 gr. 30 m.* the latitude of the place, the same extent will reach from the tangent of *65 gr. 40 m.* the declination proposed, vnto the tangent of *60 gr.* and such is the angle of inclination betweene the meridian of the place and the proper meridian of the plane, which resolued into time doth make foure houres; and so the substylar must here be placed vpon the houre of 8 in the morning.

This angle being knowne, the rest of the angles at the pole are easily gathered. For if the houre of 12 be *60 gr.* distant from the meridian of the plane, the houre of 1 will be *75 gr.* and the houre of 11, will be *45 gr.* distant, and the rest of the houres, as in the Table following. Then comming to the plane,

1 I draw an occult horizontall line *HQ*, wherein I make choice of a center *H*, and describe an occult circle for the horizon of the plane.

2 I find a chord of *55 gr. 26 m.* and inscribe it into this circle, from *Q* vnto *B*, according to the situation of the plane; so the line *HB* shall be the meridian of the plane: and therefore the substylar and the line *AC* crossing it at right angles, shall be the equator.

3 I consider the length of the plane, and how many houres I am to draw vpon it, that so I may proportion the height of the style; and I finde by the fundamentall diagram and the former table, that it will containe all the houres from Sun rising vntill 1 afternoone: and therefore the meridian of the plane falling on the houre of 8 in the morning, there will be foure houres on the one side, and fiue on the other side of the substylar. But in all polar planes the height of the style aboue the substylar must be equall to the distance of the third houre from the substylar, or about $\frac{4}{7}$ of the fourth houre, or little more then $\frac{1}{4}$ of the fift houre, and thereupon I allow the height of this style to be equall to *CB*, which you may suppose to be ten inches.



4 Because the equator *AC* is a tangent line in respect of the Radius *BC*, and the parts thereof are such as belong to the angles betweene the meridian of the plane and the hourelines, which angles are set downe in the table following, I may finde the length of each severall tangent in this maner.

As the tangent of 45 *gr.*
is to the tangent of the houre:
So the parts of the Radius,
to the parts of the tangent line.

The angle *ABC* betweene the meridian of the plane and the houre of 12, the meridian of the place is 60 *gr.* in the

Hor.	An. Po. Gr.	M.	Tangent In.	Par.
4	60	0	17	32
5	45	0	10	00
6	30	0	5	77
7	15	0	2	68
8	*Meria*		*Subftyl*	
	3	45		65
	7	30	1	32
	11	15	1	99
9	15	0	2	68
	18	45	3	39
	22	30	4	14
	26	15	4	93
10	30	0	5	77
	33	45	6	68
	37	30	7	67
	41	15	8	77
11	45	0	10	00
	48	45	11	40
	52	30	13	03
	56	15	14	97
12	60	0	17	32
	63	45	20	28
	67	30	24	14
	71	15	29	46
1	75	0	37	32
	78	45	50	27
	82	30	75	96
	86	15	152	57
2	90	0	Infinit	

the former table, and the Radius *B C* is ſuppoſed to be ten inches; whereupon I extend the compaſſes from the tangent of 45 *gr.* vnto the tangent of 60 *gr.* the ſame extent will reach from 10 in the line of numbers, vnto 17. 32, which ſhewes the length of the tangent *A C* betweene the ſubſtylar and the houre of 12, to be 17.32 *cent.* The like reaſon holds for the reſt of the houres.

5 Theſe lengths being thus found and ſet downe in the table, I take out 17 inches 32 *cent.* and prick them in the equator from *C* vnto *A* for the houre of 12, and 37 inches 32 *cent.* and prick them downe for the houre of 1. And ſo the reſt of the houre-points.

6 This done, if I draw right lines through each of theſe points, croſſing the equator at right angles, they ſhall be the houre-lines required: and if I ſet the ſtyle ouer the ſubſtylar, ſo as the edge of it may be parallell to the plane, and the height of it be ten inches equall to the former Radius *B C*, it ſhall repreſent the axis of the world, and be truly placed for caſting of the ſhadow vpon the houre-lines in this declining polar plane.

CHAP. X.

To draw the houre-lines in a declining inclining plane.

IF a plane ſhall decline from the prime verticall, and incline to the horizon, and yet not lie euen with the poles of the world, it is then called a declining inclining plane.

Of theſe there are ſeuerall ſorts; for the inclination being Northward, the plane may fall between the horizon and the pole, as the circle *B M D* in the fundamentall Diagram; or betweene the zenith and the pole, as *B F D*: or the inclination may be Southward, and ſo be repreſented by *B K D*, it may alſo fall either below the interſection of the meridian and the equator, or aboue it; and each of theſe haue two faces, the vpper toward the zenith, and the lower toward the nadir; wherein hauing the latitude of the place with the declination and inclination of the plane, we are farther to conſider,

1 The arke of the meridian betweene the pole and the plane.
2 The inclination of the plane to the meridian.
3 The arke of the plane betweene the horizon and the meridian.
4 The angle of inclination betweene both meridians.
5 The height of the pole aboue the plane.
6 The diſtance of the ſubſtylar from the meridian.
7 The diſtances of each houre-line from the ſubſtylar.

And all theſe ſeuen may be repreſented in the fundamentall diagram, as in this example.

In our latitude of *51 gr. 30 m.* a plane is propoſed, declining from the verticall 24 *gr.* 20 *m.* and inclini g Northward 36 *gr.* the vpper face lying open to the Southweſt, the lower to the Northeaſt. If I number theſe 24 *gr.* 20 *m.* in the horizon from *E* to *B*, and there draw the line BCD, it ſhall repreſent

ſent the horizontall line of the plane: then croſſing it at right angles with the plane *HZQ* drawne through the zenith, I number 36 *gr.* for the inclination from *Q* vnto *M*, and there draw the circle B M D, croſſing the meridian in the point *a*; this circle ſo drawne ſhall repreſent the plane propoſed; and becauſe it doth not paſſe through the pole, is therfore no polar, but an ordinary declining inclining plane.

1 The arke of the meridian of the place between the pole and the plane, is here repreſented by *P a*, and may be found by reſoluing the triangle D N *a*, wherein the angle at *N* is knowne to be a right angle, the angle at D is the angle of inclination, the ſide D N the complement of the declination, which being knowne,

As the ſine of 90 *gr.*
to the coſine of declination:
So the tangent of inclination to the horizon,
to the tangent of the meridian betweene the horizon and the plane.

Extend the compaſſes from the ſine of 90 *gr.* vnto the ſine of 65 *gr.* 40 *m.* the complement of the declination, the ſame extent will reach from the tangent of 36 *gr.* the inclination propoſed, vnto the tangent of 33 *gr.* 30 *m.* and ſuch is the ark of the meridian *N a* between the horizon and the plane. This arke *N a* being compared with the arke *N P*, which is the eleuation of the pole aboue the horizon, and is here ſuppoſed to be 51 *gr.* 30 *m.* the difference *N a* cometh to 18 *gr.* and ſuch is the arke of the meridian required betweene the pole and the plane.

2 The inclination of the plane to the meridian is here repreſented by the angle N *a* D, and may be found by that which we haue giuen in the former triangle D N *a*. For

As the ſine of 90 *gr.*
to the ſine of the declination from the verticall:
So the ſine of inclination to the horizon,
to the coſine of the inclination to the meridian.

Extend the compaſſes from the ſine of 90 *gr.* vnto the ſine of

of 24 *gr.* 20 *m.* the declination of the plane, the same extent will reach from the sine of 36 *gr.* the inclination giuen, vnto the cosine of 76 *gr.* And such is N *a* D the angle of inclination betweene the plane D *a*, and N *a* the meridian of the place. Or

As the sine of the arke of the meridian betweene the horizon and the plane,
is to the sine of 90 *gr.*
So the cotangent of the declination
to the tangent of the inclination to the meridian.

Extend the compasses from the sine of 33 *gr.* 30 *m.* the ark of the meridian betweene the horizon and the plane, vnto the sine of 90 *gr.* the same extent will reach from the tangent of 65 *gr.* 40 *m.* the complement of the declination vnto the tangent of 76 *gr.* And such is the inclination of the plane to the meridian, the same as before.

3 The arke of the plane betweene the horizon and the meridian, is here represented by D *a*, and may also be found by that which we haue giuen in the former triangle D N *a*.

As the sine of 90 *gr.*
to the cosine of inclination to the horizon:
So the cotangent of the declination
to the tangent of the plane required.

Extend the compasses from the sine of 90 *gr.* vnto the sine of 54 *gr.* the complement of the inclination of the plane to the horizon, the same extent will reach from the tangent of 65 *gr.* 40 *m.* the complement of the declination, vnto the tangent of 69 *gr.* 54 *m.* And such is D *a* the arke of the plane, betweene the horizon and the meridian of the place.

4 The inclination of meridians is here represented by the angle *a P b*. For if I let downe a perpendicular *Pb* from the pole vnto the plane, this perpendicular shall be the meridian of the plane; and we shall haue another triangle *a b P*, wherein the angle at *b* is a right angle, because of the perpendicular, the angle at *a* is the inclination of the plane to the meridian of the place, and the side *P a* is the arke of the meridian

meridian betweene the pole and the plane, which being knowne,

As the cosine of the arke of the meridian betweene the pole and the plane
is to the sine of *90 gr.*
So the cotangent of the inclination to the meridian,
to the tangent of inclination of the meridian of the plane to the meridian of the place.

Extend the compasses from the sine of *72 gr.* the complement of the arke *Pa*, betweene the pole and the plane, vnto the sine of *90 gr.* the same extent wil reach from the tangent of *14 gr.* the complement of the inclination of the plane to the meridian, vnto the tangent of *14 gr. 41 m.* And such is the angle *a P b* of inclination betweene the meridian of the place and the proper meridian of the plane, which resolued into time, doth make about *59 minutes*, and so the substylar must here be placed neare the houre of 1 after noone.

5 The height of the pole aboue the plane is here represented by *Pb*, the arke of the proper meridian between the pole and the plane, and may be found by that which wee haue giuen in the triangle *a b P*. For

As the sine of *90 gr.*
to the sine of the meridian of the place betweene the pole and the plane:
So the sine of the inclination to the meridian,
to the sine of the height of the pole aboue the plane.

Extend the compasses from the sine of *90 gr.* vnto the sine of *18 gr.* the arke *P a* of the meridian of the place from the pole to the plane, the same extent wil reach from the sine of *b a P* the inclination of the plane to the meridian of the place, vnto the sine of *17 gr. 26 m.* Or

As the sine of *90 gr.*
to the cosine of inclination of meridians:

So

So the tangent of the meridian of the place betweene the pole and the plane,
to the tangent of the height of the pole aboue the plane.

Extend the compasses from the sine of *90 gr.* vnto the sine of *75 gr. 19 m.* the complement of *a P b* the inclination of the two meridians, the same extent will reach from the tangent of 18 *gr.* the arke *P a* of the generall meridian between the pole and the plane, vnto the tangent of 17 *gr. 26 m.* And such is *P b* the height of the pole aboue the plane; and such must be the height of the style aboue the substylar.

6 This distance of the substylar from the meridian of the place, is here represented by *a b* the arke of the plane betweeen the two meridians, and may be found by that which we had giuen at the first in the former triangle *a b P.* For

As the sine of *90 gr.*
to the sine of the inclination to the meridian:
So the tangent of the meridian of the place betweene the pole and the plane,
vnto the tangent of the substylar from the meridian of the place.

Extend the compasses from the sine of *90 gr.* vnto the sine of 14 *gr.* the complement of *b a* P, the inclination of the plane to the meridian, the same extent will reach from the tangent of 18 *gr.* the arke of the generall meridian betweene the pole and the plane, vnto the tangent of 4 *gr.* 30 *m.* And such is the arke of the plane betweene the two meridians; and such must be the distance from the houre of 12 to the substylar.

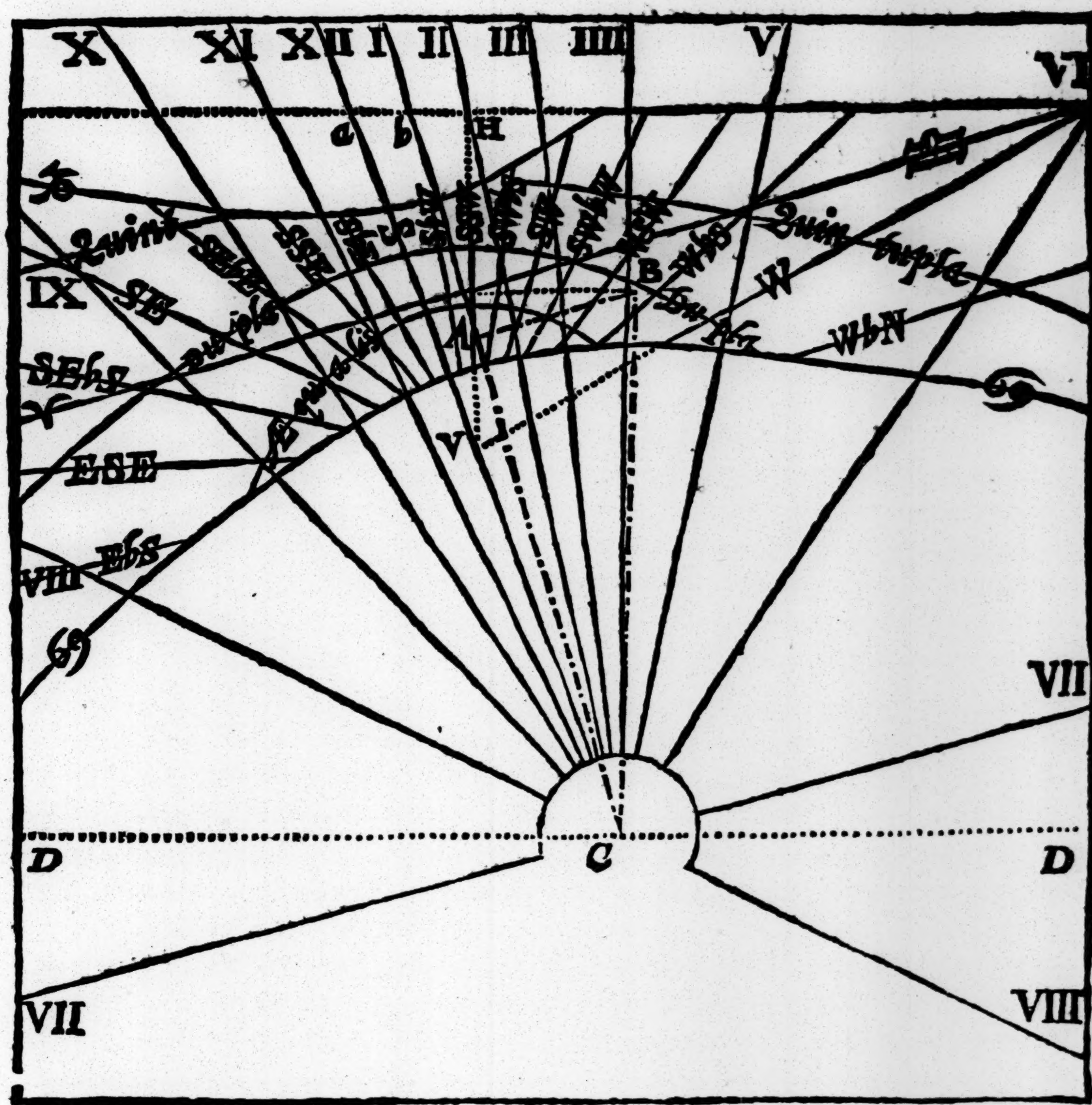
7 The distances of the houre-lines from the substylar, are here also represented by those arks of the plane, which are

Hor.	Ang. Po. Gr.	Ang. Po. M.	Arc. Pla. Gr.	Arc. Pla. M.
7	89	41	88	57
8	74	41	47	35
9	59	41	27	9
10	44	41	16	31
11	29	41	9	41
12	14	41	4	30
	Merid.		*Substyl*	
1	0	19	0	6
2	15	19	4	42
3	30	19	9	56
4	45	19	16	52
5	60	19	27	45
6	75	19	48	51

are intercepted between the proper meridian and the houre-circles. For in these triangles the angle at *b* betweene the plane and the proper meridian is a right angle, the side P*b* is the height of the pole aboue the plane, and then the angles at the pole between the proper meridian and the houre-circles being gathered into a table.

As the sine of *90 gr.*
to the sine of the pole aboue the plane:
So the tangent of the angle at the pole,
to the tangent of the houre-line from the substylar.

Extend the compasses from the sine of *90 gr.* vnto the sine of 17 *gr.* 26 *m.* the height of the pole aboue the plane, the



same extent will reach from the tangent of 14*gr.* 41 *m.* the angle at the pole belonging to the houre of 12, vnto the tangent of 4 *gr.* 30 *m.* for the arke of the plane betweene the substylar and the houre of 12; and frō the tangent of 29 *gr.* 41 *m.* vnto the tangent of 9 *gr.* 41 *m.* for the houre of 11, and so for the rest of the arks of the plane between the substylar and the houre-lines, as in the former table.

These arkes being thus found, will serue for the drawing of the houre-lines on either side of the plane: but supposing it to be the vpper side, I consider how the lines doe fall in the fundamentall diagram, and accordingly

1 I draw an occult horizontall line DD, wherein I make choice of the center *C*, and thence draw an occult circle for the horizon of the plane.

2 I finde a chord of 69 *gr.* 54 *m.* the arke of the plane betweene the horizon and the meridian, and inscribe it into ~~this circle from~~ D vnto *a*, and there draw the line *C a* for the houre of 12.

3 I finde a chord of 4 *gr.* 30 *m.* the arke of the plane betweene the two meridians, and inscribe it into this circle from *a* vnto *b*, and there draw the line *C b* for the substylar.

4 The substylar being drawne, I may inscribe the chords of the arkes of the plane from the substylar, and draw the houre-lines, and set vp the style as in the former planes.

A second example of a Plane falling betweene the pole and the zenith.

In like maner if in our latitude a plane be proposed declining from the verticall 24 *gr.* 20 *m.* as before, but inclining to the horizon 75 *gr.* 40 *m.* Northward, the vpper face being opē to the Southwest, the lower to the Northeast, this plane shall be here represented by the circle BFD, crossing the meridian in the point *d*, between the pole and the zenith, and the proper meridian of this plane, by the perpendicular arke P *e*.

Then in this triangle D N *d* knowing the side D N the comple-

complement of the declination, with the angle of inclination to the horizon at D, and the right angle at N, these former Canons will giue *N d* the arke of the meridian between the horizon and the plane to be 74 *gr.* 20 *m*; and therfore *P d* the arke of the meridian betweene the pole and the plane will be 22 *gr.* 50 *m.* the angle *D d N* of the inclination of the plane to the meridian, will be found to be 66 *gr.* 29 *m.* and *D d* the arke of the plane between the horizon and the meridian 83 *gr.* 36 *m.*

Againe, in the triangle *P e d* knowing the side *P d* the arke of the meridian betweene the pole and the plane, with the angle of inclination to the meridian at *d*, and the right at *e*, the angle *d P e* of the inclination of the two meridians will be found to be 25 *gr.* 17 *m.* and *P e* the height of the pole aboue the plane to be 20 *gr.* 50 *m.* and *d e* the distance of the substylar from the meridian about 9 *gr.* 32 *m.*

Declinatiõ	24	20
Inclinatiõ	75	40
Diff. meri.	83	36
dist. substy	9	32
Alti. Styl.	20	50

Hor.	Ang. Po. Gr.	Ang. Po. M.	Arc. Pla. Gr.	Arc. Pla. M.
8	85	17	76	56
9	70	17	44	47
10	55	17	27	11
11	40	17	16	43
12	25	17	9	32
1	10	17	3	41
	Merid		*Substyl*	
2	4	43	1	40
3	19	43	7	16
4	34	43	13	50
5	49	43	22	46
6	64	43	37	0
7	79	43	62	58

Lastly, hauing found the height of the pole aboue the plane, and gathered the angles at the pole, the arks of the plane from the substylar to the houre-lines will be as in this table.

This done, if we consider how the lines doe fall in the fundamentall diagram, we may there see how the North pole is eleuated aboue the lower face, & the South pole aboue the vpper face of the plane, and accordingly make choice of a center, draw the horizontall, ỷ meridian, the substylar, & the houre-lines, and set vp the style as in the other planes.

A third example of a Plane inclining to the Southward.

If in our latitude a plane were pro-

poſed declining from the verticall 24 *gr.* 20 *m.* as before, but inclining to the horizon 14 *gr.* 20 *m.* Southward, the vpper face being open to the Northeaſt, the lower to the Southweſt, this plane ſhall be here repreſented by the circle *BKD* croſſing the meridian in the point *f* betweene the equator and the horizon, and the proper meridian of this plane by the perpendicular arke *Pg* let downe from the pole to the plane, neare the houre of 11, at the North part of the horizon, as may partly appeare by the neareſt extent of the compaſſes.

Then in the triangle B*Sf*, knowing the ſide *BS* the cōplement of the declination, with the angle of inclination to the horizon at B, and the right angle at *S*, we may find *Sf* the ark of the meridian betweene the horizon and the plane to be 13 *gr.* 6 *m.* And therefore *Pf* the arke of the meridian betweene the pole and the plane to the Southward 115 *gr.* 24 *m.* but 64 *gr.* 36 *m.* to the Northward, the angle B*f*S or D*f*N of the inclination of the plane to the meridian, will be found 84 *gr.* 9 *m.*; & B*f* or D*f* the arke of the plane between the horizon & the meridian 66 *gr.* 20 *m.*

Declinatiō	24	20
Inclinatiō	14	20
diff. merid	13	27
diſt. ſubſty	12	8
Alt. Styl.	64	0

Hor.	Ang. Po		Arc. Pla.	
	Gr.	M.	Gr.	M.
6	76	33	75	6
7	61	33	58	56
8	46	33	43	30
9	31	33	28	55
10	16	33	14	58
11	1	33	1	25
	Merid		*Subſtyl*	
12	13	27	12	8
1	28	27	25	57
2	43	27	40	23
3	58	27	55	38
4	73	27	71	41
5	88	27	88	15

Again, in the triangle *Pgf* knowing the ſide *Pf* the arke of the meridian betweene the pole and the plane, with the angle of inclinatiō to the meridian at *f*, and the right angle at *g*, the angle *fPg* of the inclination of the two meridians wil be found to be 13 *gr.* 27 *m.* and *Pg* the height of the pole aboue the plane, about 64 *gr.* and *fg* the diſtance of the ſubſtylar from the meridian 12 *gr* 8 *m.*

Hauing found the height of the pole aboue the plane, and gathered the angles at the pole, the arkes of the plane from the ſubſtylar to the houre-lines will be found as in this table.

This

This done, if we consider how the lines do fall in the fundamentall diagram, we may there see how the North pole is eleuated aboue the vpper face, and the South pole aboue the lower face of this plane, and accordingly make choice of the center, draw the horizontall, the meridian, the substylar, and the houre-lines, and set vp the style as in the former planes.

CHAP. XI.

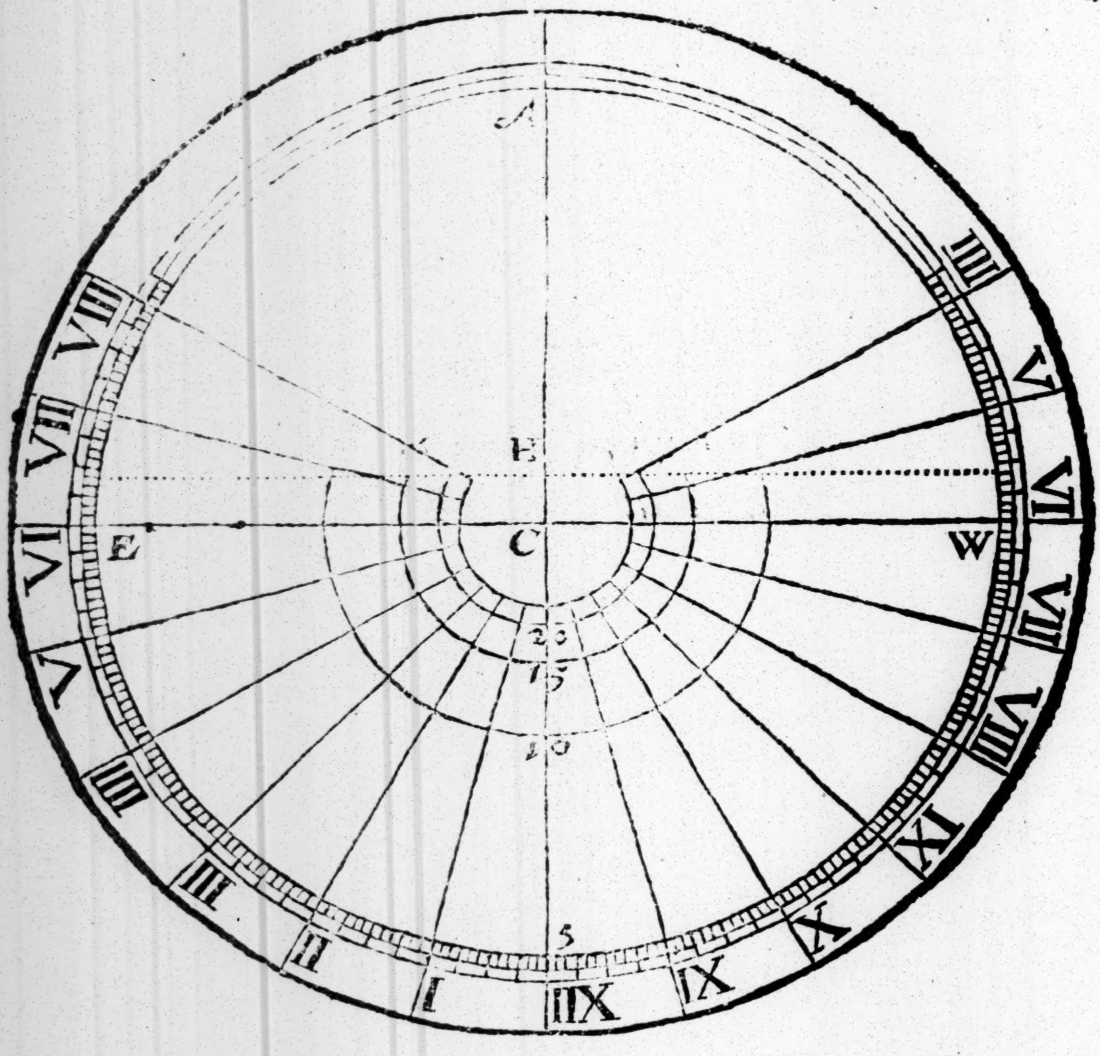
To describe the Tropiques and other circles of declination in an equinoctiall Plane.

SVch circles as are parallell to the equinoctiall, and yet fall within the tropiques, may be described on any plane by help of these lines of proportion, but after a different maner, according as the style shall be either perpendicular, or parallel to the plane, or cut the plane with oblique angles.

In an equinoctiall plane where the style is perpendicular to the plane, the tropiques and other circles of declination will be perfect circles: wherefore consider the length of the style in inches and parts, and the declination of the circle which you intend to describe in degrees and minutes, the proportion will hold,

As the tangent of 45 *gr.*
to the length of the style:
So the cotangent of the parallell,
to the semidiameter of his circle.

Suppose the length of the style aboue the plane to be 10 inches, and that it were required to finde the semidiameter of the tropique, whose declination is knowne to be 23 *gr.* 30 *m*: extend the compasses from the tangent of 45 *gr.* vnto the tangent of 66 *gr.* 30 *m.* the same extent will reach in the line of numbers from 10 vnto 23, which shewes the semidiameter of the tropique to be 23 inches. So if the declination be 20 *gr.* the semidiameter will be 27 inches 47 *cent*; if



15 *gr.* then 37.32; if 10 *gr.* then 56.71; if 5 *gr.* then 114.30; and so in the rest.

Or if it were required to proportion the style to the plane,

As the tangent of 45 *gr.*
to the tangent of the declination:
So the semidiameter of the plane,
to the length of the style.

As if the semidiameter of the greatest parallell vpon the plane were but six inches, and that parallell should be the fift degree of declination: extend the compasses from the tangent of 45 *gr.* vnto the tangent of 5 *gr.* the same extent wil reach in the line of numbers from 6.00 vnto about 0.53, which

which ſhewes that the length of the ſtyle muſt be 53 parts of an inch diuided into 100; then the length of the ſtyle being knowne, the ſemidiameter of the other circles will be found as before.

I begin here with the fift parallell, and thence proceed vnto the tropique, becauſe the ſhadow of the reſt neare the equinoctial, would be ouerlong, and the equinoctiall it ſelfe cannot be deſcribed. The parallels of North declination are to be ſet on the North face, and the parallels of South declination on the South face of the plane. Neither need theſe parallels to be drawne in full circles, but onely to the horizontall line, which ſhall be deſcribed in *Cap.* xviij.

Hauing by theſe meanes ſet vp the ſtyle to his true height, and drawne the circles of declination, if we ſhall place the plane ſo as it ſhall make an angle with the horizon equall to the cõplement of the latitude, and then turne it vntil the top of the ſtyle caſt the ſhadow vpon the parallell of declination belonging to ỹ time, the meridian of the plane will ſhew the meridian of the place, and the ſhadow of the ſtyle the houre of the day, without the help of a magneticall needle.

CHAP. XII.

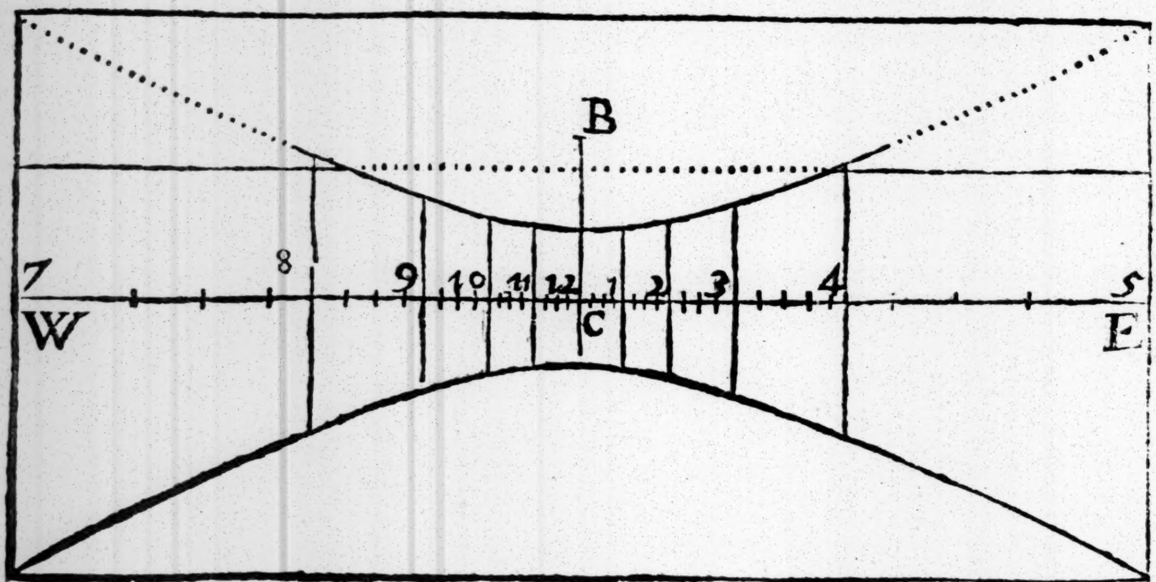
To deſcribe the Tropiques and other circles of declination in a polar plane.

IN all polar planes, whether the be parallel to the meridian or to the circle of the houre of 6, or otherwiſe declining, the equinoctiall will be a right line, but the tropiques and other circles of declination wil be ſections hyperbolicall, and be thus deſcribed.

Conſider the length of the ſtyle, the declination of the parallell, and the angle at the pole betweene the ſubſtylar and the houre-line, whereon you meane to deſcribe the parallell.

If you would find where the parallels doe crosse the substylar;

As the tangent of 45 *gr.*
to the tangent of declination:
So is the length of the style,
to the distance of the parallell from the equinoctiall.

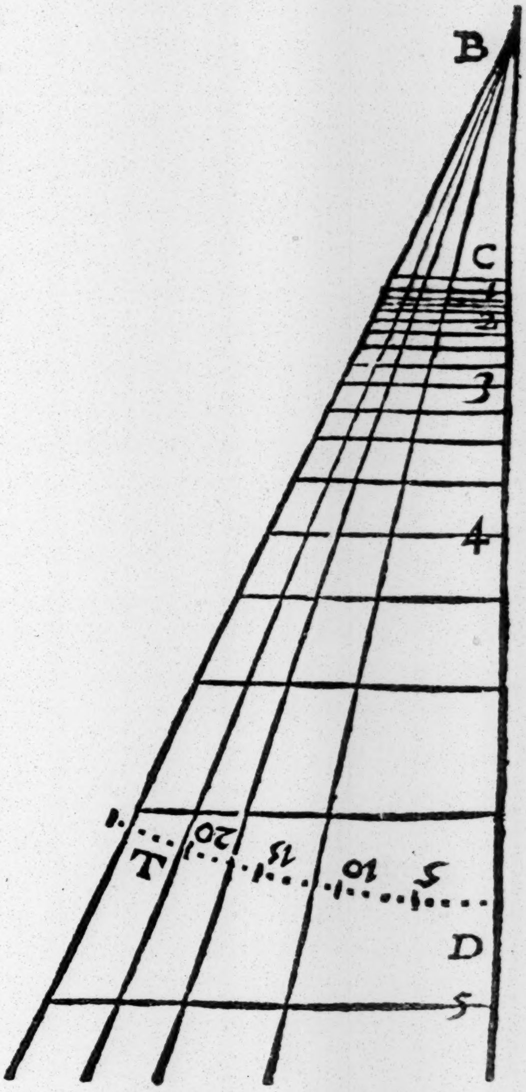


As in the example of the polar plane, where the length of the style *B C* was found to be 1 inch 61 *cent.* if you desire to know the distance betweene the equinoctiall and the tropique vpon the substylar line: extend the compasses from the tangent of 45 *gr.* vnto the tangent of 23 *gr.* 30 *m.* the same extent will reach in the line of numbers from 1.61 vnto 0.70; and therefore the distance required is 70 parts of an inch diuided into 100. The like reason holdeth for all other parallels of declination crossing the substylar.

But if you would finde where the parallels doe crosse any other of the houre-lines, first find the distance betweene the axis of the style and the houre-line, then the distance betweene the equinoctiall and the parallell, both these may be represented in this maner.

On the center *B* and any semidiameter *B D* describe an occult arke of a circle, and therein describe a chord of 23 *gr.* 30 *m.*

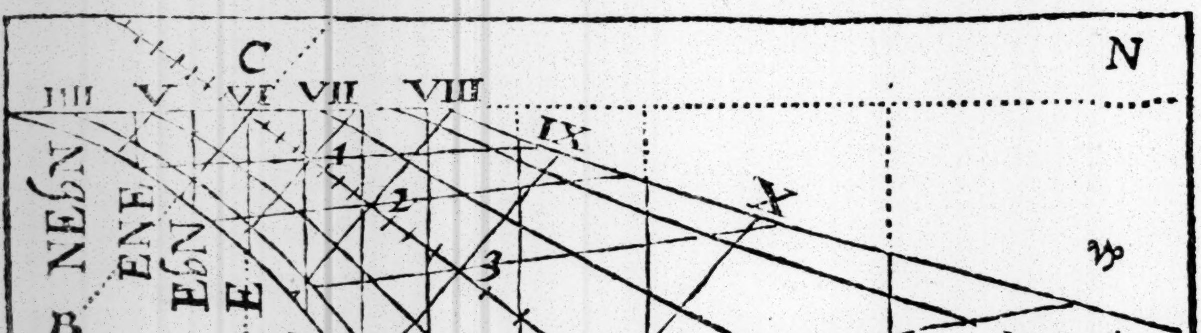
30 *m.* from *D* vnto *T*, with such other intermediate declinations as you intend to describe on the plane, so the line B D shall be the equator, and B T the tropique, and the other intermediate lines the lines of declination.



That done, consider your plane, which for example may be either the meridian or ye declining polar plane, wherein hauing drawne both the equator, and the houre-lines as before, first take out the height of the style, and prick that downe in this equator from *B* vnto *C*; then take out all the distances, betweene *B* the top of the style and the seuerall points wherein the houre-lines doe crosse the equator, transfer them into this equator B D from the center *B*, and at the termes of these distances erect lines perpendicular to the equator, crossing the lines of declination, and note them with the number of the houre from whence they were taken: so these perpendiculars shal represent those houre-lines, and the seuerall distances between the equator and the lines of declination, shall giue the like distances between the equator and the parallels of declination vpon your plane. Vpon this ground it followeth,

To find the distance betweene the axis and the houre-lines.

As the cosine of the houre from the substylar,
is to the sine of 90 *gr.*
So the length of the style,
to the distance between the axis and the houre-line.



As if in the former example of the meridian plane, where *B C* the height of the style is supposed to be 10 inches, it were required to find the distance between *B* the top of the style and the point wherein the houre of 11 in the morning doth crosse the equator, which is here represented by *B* 5, because it is the fift houre from the substylar, whose angle at

the

the pole is 75 *gr.* Extend the compasses from the sine of 15 *gr.* the complement of the fift houre from the substylar, vnto the sine of 90 *gr.* the same extent wil reach from 10.00 in the line of numbers vnto 38.64; and therefore the distance *B* 5 between the axis and the houre-line, is 38 inches & 64 *cent.* and may be called the secant of the houre. Then in the rectangle B 5 T, hauing the side B 5, and the angle of declination at B.

To finde the distance betweene the equinoctiall and the parallell.

As the tangent of 45 *gr.*
 to the tangent of the declination:
So the distance betweene the axis and the houre-line,
 to the distance between the equinoctiall and the parallell.

Extend the compasses from the tangent of 45 *gr.* vnto the tangent of 23 *gr.* 30 *m.* the declinatiō of the tropique, so the same extent will reach in the line of numbers from 38.64, the distance between the axis and the fift houre-line vnto 16.80; and therefore the distance is 16 inches and 80 *cent.* The like reason holdeth for all the rest, which may be gathered and set downe in such a Table as this which followeth.

Wherein I haue set downe these distances for seuerall declinations, for 11 *gr.* 30 *m.* for 16 *gr.* 55 *m.* for 20 *gr* 12 *m.* for 21 *gr* 41 *m.* and for the declination of the Tropique 23 *gr.* 30 *m.* which may be applied to the like declinations in all meridian and direct polar planes.

As in the former example of the polar plane, where *B C* the height of the style is found to be 1 inch 61 *cent.* if it were required to find the distance betweene B the top of the style and the points wherein the houre-lines of 7 in the morning or 5 after noon, do crosse the equator (which distances, I called the secants of those houres.) either you may extend the compasses from the sine of 15 *gr.* the complement of the houre from the substylar vnto the sine of 90 *gr.* so the same

Ho.	Ang. Po. Gr.	M.	Tangent In.	Par.	Secant In.	Pa.	11 30 In.	Pa.	10 55 In.	Pa.	20 12 In.	Pa	21 41 In.	Pa.	23 30 In.	Pa
0	0	0	0	0	10	0	2	3	3	4	3	68	3	98	4	35
	3	45	0	65	10	02	2	04	3	05	3	69	3	99	4	36
	7	30	1	32	10	09	2	05	3	07	3	71	4	01	4	39
	11	15	1	99	10	20	2	07	3	10	3	75	4	05	4	43
1	15	0	2	68	10	35	2	10	3	15	3	81	4	12	4	50
	18	45	3	39	10	56	2	15	3	21	3	89	4	20	4	59
	22	30	4	14	10	82	2	20	3	29	3	99	4	30	4	70
	26	15	4	93	11	15	2	26	3	39	4	10	4	43	4	85
2	30	0	5	77	11	55	2	34	3	51	4	24	4	60	5	02
	33	45	6	68	12	03	2	44	3	66	4	42	4	78	5	23
	37	30	7	67	12	60	2	56	3	83	4	64	5	02	5	48
	41	15	8	77	13	30	2	70	4	05	4	89	5	29	5	78
3	45	0	10	00	14	14	2	87	4	30	5	20	5	63	6	15
	48	45	11	40	15	17	3	08	4	62	5	58	6	03	6	00
	52	30	13	03	16	43	3	34	5	00	6	04	6	54	7	14
	56	15	14	97	18	00	3	66	5	48	6	62	7	00	7	83
4	60	0	17	32	20	00	4	07	6	08	7	36	7	95	8	70
	63	45	20	28	22	61	4	60	6	88	8	32	9	00	9	83
	67	30	24	14	26	13	5	31	7	95	9	61	10	39	11	36
	71	15	29	46	31	11	6	33	9	47	11	45	12	37	13	53
5	75	0	37	32	38	64	7	86	11	74	14	20	15	36	16	80
	78	45	50	27	51	26	10	43	15	60	18	89	20	38	22	28
	82	30	75	96	76	61	15	58	23	32	28	19	30	47	33	31
	86	15	152	57	152	90	31	10	46	54	56	26	60	81	66	48
6	90	0	Infin.		Infin.		Infin.		Infin.		Infin.		Infin.		Infin.	

extent wil reach in the line of numbers from 1.61 the length of the style, vnto 6.21, according to the former Canon. Or else you may make vse of the former Table, extending the compasses in the line of numbers from 10.00 the length of the style in the Table, vnto 1.61 the length of the style belonging to your plane, so the same extent shall reach from from 38.64 the secant in the Table, vnto 6.21, and such is your secant required, the distance betweene the top of the

style

ſtyle and the point of interſection, wherein the fift houre line from the ſubſtylar doth croſſe the equator.

Again, the ſame extent will reach from 16.80 the diſtance in the Table belonging to the fift houre-line betweene the equator and the parallell of 23 *gr.* 30 *m.* declination, vnto 2.70 for the like diſtance vpon your plane; and ſo for the reſt, which may be gathered and ſet downe in a Table.

That done, and the equator drawne as before, if you would draw the tropiques in the polar plane, looke into the Table, and take 70 *cent.* out of the line of inches, and pricke them downe in the ſubſtylar on either ſide of the equator, and ſo 72 *cent.* on the firſt houre, and 80 on the ſecond houre, and 2 inches 70 *cent.* on the fift houre from the ſubſtylar, and the reſt of theſe diſtances on their ſeuerall houre-lines, and then draw a crooked line through all theſe points, ſo as it makes no angles, the line ſo drawne ſhall be the Tropique required. In like maner you may draw any other parallell of declination.

Hor.		An. Po Gr.	M	Tang In.	P.	Secant In.	P.	Trop. In	P.
12		0	0	0	0	1	61	0	70
11	1	15	0	0	43	1	63	0	72
10	2	30	0	0	93	1	85	0	80
9	3	45	0	1	61	2	27	0	99
8	4	60	0	2	79	3	22	1	40
7	5	75	0	6	00	6	21	2	70

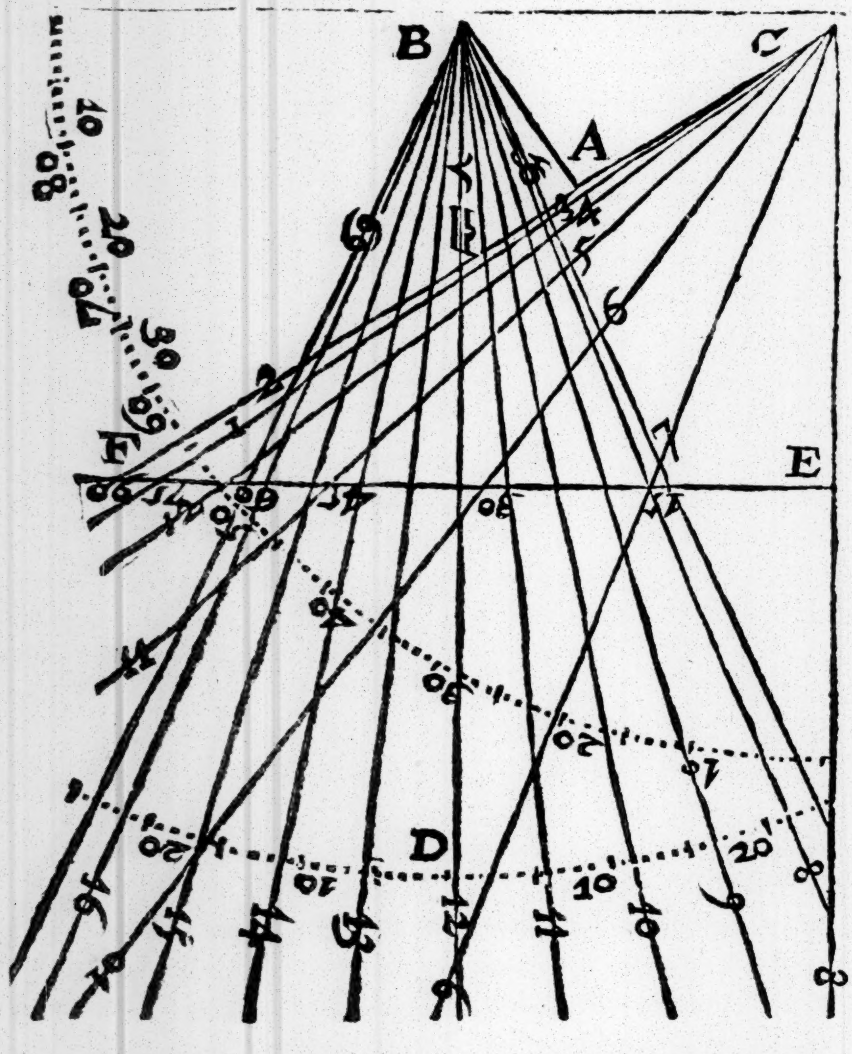
CHAP. XIII.

To deſcribe the Tropiques and other circles of declination in ſuch a Plane as is neither equinoctiall nor polar.

IN Planes neither equinoctiall nor polar, the equator will be a right line, the tropiques and other parallels of declination will be conicall ſections, ſome of them parabolicall, ſome ellipticall, but the moſt of them hyperbolicall.

To finde the points of interſection of theſe parallels with the houre-lines, wee are to conſider, firſt the length of the

axis of the style in inches and parts of inches; secondly the height of the style aboue the plane; thirdly the angles at the pole betweene the proper meridian and the houre-circles. These being knowne, will help vs to find, first the angle betweene the axis and the houre-lines on the plane; and then the distance betweene the center and the parallels: both these may be represented in this maner.



Let the triangle *A B C* be made equal to the style belonging to your plane, *A C* the substylar, *B C* the axis of the style, AB the length of the style perpendicular to the plane. Then hauing drawn the line BD perpẽdicular to the axis on the cẽter B, & any semidiameter B D describe an occult ark of a circle, and therein inscribe a chord of 23 *gr.* 30 *m.* from *D* vnto *T*, on either side of the line, with such other intermediate declinations as you intend to describe on the plane, so the perpendicular

dicular B D shall be the equator, and B T the tropiques, and the other intermediate lines the parallels of declination. Wherefore you may take out the distance C ♈ from the center to the equator, and pricke it downe on the substylar of your plane from the center at *C* vnto ♈, so the line drawne through ♈ perpendicular to your substylar, shal be the equator of your plane.

That done, take the distance of each houre-line betweene the center and the equator of your plane, and pricke them downe in the equator of this figure, from the center at *C*, noting the place, where they crosse the equator, with the number belonging to the houre, and drawing the houre-lines from *C* through the lines of declination.

Or hauing the *Sector* you may draw an occult line *C E* perpendicular to the axis B C, and therein pricke downe the tangent of the height of the style aboue the plane, from *C* vnto *E*. Then draw the line *E F* parallell to the axis, crossing the substylar produced in the point *F*, this line *EF* will be the line of sines vpon the *Sector*, and therein you may pricke downe the sines of the complement of the angles at the pole from *E* toward *F*, and draw the houre-lines by those points through the lines of declination, so the angles at *C* betweene the axis B C and those houre-lines, shall be the angles betweene the axis of your style and the houre-lines on your plane, and the seuerall distances betweene the point *C* and the lines of declination, shall giue you the like distances betweene the center, and the parallels of declination vpon the houre-lines in your plane. Vpon this ground it followeth,

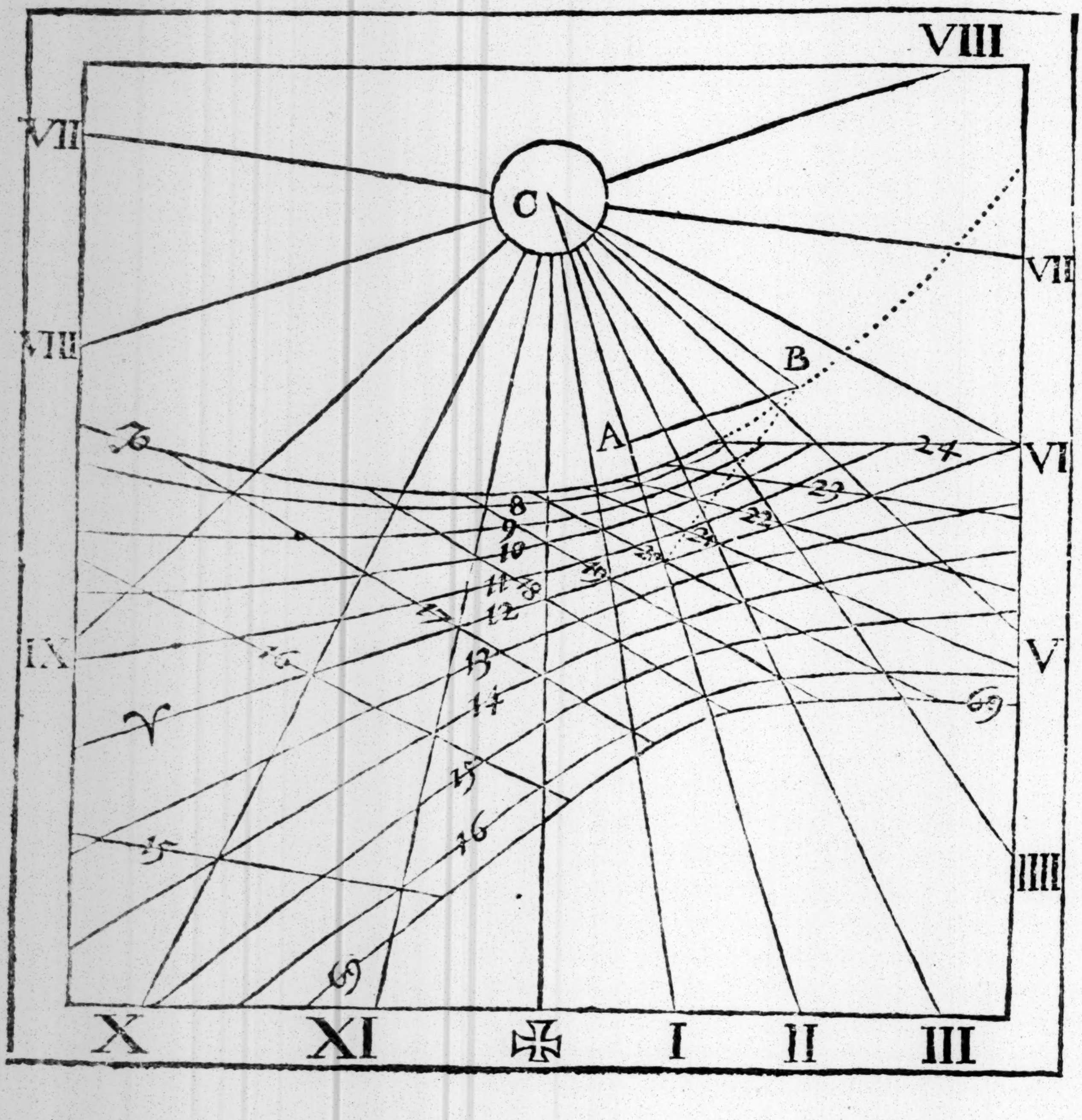
1 *To proportion the style vnto the plane.*

Consider the height of the style aboue the plane, and the length of the substylar betweene the center and the place which you intend for the tropique. If it be the tropique which is farthest from the center, adde 113 *gr.* 30 *m*: if the nearer tropique, adde 66 *gr.* 30 *m* vnto the height of the style, the remainder vnto 180 *gr.* shall giue you the altitude of the Sun

aboue

aboue the plane when he commeth to that tropique. As in our latitude the height of the ſtyle aboue an horizontall plane is 51 *gr.* 30 *m.* adde vnto this 113 *gr.* 30 *m.* the ſumme is 165 *gr.* which being taken out of 180 *gr.* the remainder wil be 15 *gr.* and ſuch is the altitude of the Sun aboue this plane when he commeth to be in the Winter tropique: but if you adde 66 *gr.* 30 *m.* vnto 51 *gr.* 30 *m.* the remainder to 180 *gr.* will be 62 *gr.* And ſuch is the altitude of the Sunne in the Summer Tropique. Then

As the ſine of 66 *gr.* 30 *m.*
  to the ſine of the Sunnes altitude:
So the length of the ſubſtylar line,
  to the length of the axis of the ſtyle.



As in the first example of the declining verticall, where the height of the style was found to be 34 *gr.* 33 *m.* and is here represented before *pag.* 150. by the angle *BC* ♋; adde to this height 113 *gr.* 30 *m.* for the angle *CB* ♋, the sum wil be 148 *gr.* 3 *m.* and the remainder to 180 *gr.* wil be 31 *gr.* 57 *m.* and such is the angle *B* ♋ *C* of the altitude of the Sun aboue the plane, when he cometh to be in the tropique of ♋, which is here the farthest tropique from the center.

Then supposing the length of the substylar line between the center and the place which is fit for the farthest tropique to be about 21 inches, extend the compasses from the sine of 66 *gr.* 30 *m.* vnto the sine of 31 *gr.* 57 *m.* the same extent will reach in the line of numbers from 21 vnto 12.11, and so the length of the axis of the style should be 12 inch. 11 *cent.* Or it may suffice to make it iust 12 inches, as a more easie ground for the rest of the worke.

But if it were required to proportion the style vnto the plane, so as it may cast the shadow to the ful lēgth of the substylar line at all times of the yeare, you may then consider the Sunne in the tropique, which is to be set nearest vnto the center, and adde 66 *gr.* 30 *m.* vnto 34 *gr.* 33 *m.* so the remainder vnto 180 *gr.* will be 78 *gr.* 57 *m.* And if you extend the compasses from the sine of 66 *gr.* 30 *m.* vnto the sine of 78 *gr.* 57 *m.* the same extent will reach in the line of numbers from 21 vnto 22 47 for the length of the axis of the style.

2 *Hauing the length of the axis, and the height of the style aboue the plane, to find the length of the sides of the style.*

The style of a plane neither equinoctiall nor polar, may be either a small rod of iron set parallell to the axis of the world, or perpendicular to the plane, or else a thin plate of iron or brasse made in forme of a rectangle triangle *BAC*, with the base *BC* parallell to the axis of the world, the side *AB* perpendicular to the plane, & the side *AC* the same with the substylar line, wherein knowing *BC*, and the angle BAC,

As the sine of 90 *gr.*
to the length of the axis:
So the sine of the height of the style,
to the length of the perpendicular side:
And so the cosine of the height of the style,
to the length of the substylar side.

Thus in the former example, the length of the axis being supposed to be 12 inches, and the height of the style 34 *gr.* 33 *m.* Extend the compasses from the sine of 90 *gr.* (or else from the sine of 5 *gr.* 45 *m.*) vnto 12 in the line of numbers, the same extent will reach from the sine of 34 *gr.* 33 *m.* vnto 6.80 in the line of numbers for the length of the perpendicular side, and from the sine of 55 *gr.* 27 *m.* vnto 9.88 for the length of the substylar side.

3 *To find the distance between the center and the equator vpon the substylar line.*

This is here represented by C ♈, and may be found by resoluing the rectangle triangle C B ♈.

As the cosine of the height of the style,
is to the sine of 90 *gr.*
So the length of the axis,
to the distance of the equator from the center.

Extend the compasses from the sine of 55 *gr.* 27 *m.* vnto the sine of 90 *gr.* the same extent will reach in the line of numbers from 12 vnto 14.57. Wherefore if you take 14 *inch.* 57 *cent.* and pricking them down on your substylar line frō C vnto ♈, draw a line through ♈, crossing the substylar at right angles, the line so drawne shall be the equator.

4 *To find the angles contained between the equator and the houre-lines vpon your plane.*

These angles made by B ♈ and the houre-lines, are complements

plements of those which are at C, betweene B C the axis and those seuerall houre-lines, and depend vpon the angles at the pole, between the proper meridian and the houre-circles.

As the sine of 90 *gr.*
to the cosine of the angle at the pole:
So the cotangent of the height of the style,
to the tangent of the angle between the equator and the houreline.

In our example the height of the style is 34 *gr.* 33 *m.* and the proper meridian falleth to be the same with the circle of the second houre after noone, whereupon the angle at the pole, betweene this proper meridian, and the circles of the houre of 1 on the one side, and 3 on the other side, wil be 15 *gr*; so between this meridian and the houre-circles of 12 and 4, the angle will be 30 *gr.* &c. as in the Table.

Ho.		An. Po		Arc. Pla.		An. Equ		C ♈		C ♋		C ♑	
		Gr.	M.	Gr.	M.	Gr.	M.	In.	P.	In.	P.	In.	P.
substy		0	0	0	0	55	27	14	57	20	80	11	21
1	3	15	0	8	38	54	50	14	74	21	36	11	25
12	4	30	0	18	8	51	30	15	33	23	44	11	40
11	5	45	0	29	33	45	45	16	75	29	06	11	76
10	6	60	0	44	30	36	0	20	00	50	84	12	77
9	7	75	0	64	42	20	36	34	10	Infin.		15	82
8	8	90	0	90	0	0	0	Infinit				27	60

If then it be required to find the angle, which the houre-line of 4 after noone doth make with the plane of the equator, that is the angle C 4 B contained betweene the houre-line C 4 and the line B 4, drawne from the top of the style vnto the intersectiō of the houre-line of 4 with the equator.

Extend the compasses from the sine of 90 *gr.* vnto the sine of 60 *gr.* the complement of the angle at the pole, the same extent wil reach from the tangent of 55 *gr.* 27 *m.* the complement of the height of the pole, vnto the tangēt of 51 *gr.* 30 *m.*

and such is the angle C 4 B in the diagram *Pag.* 150.

Or in crosse-worke, if it were required to finde the angle C 9 B, looke into the Table for the houre of 9, and there you shall find the angle at the pole to be 75 *gr*; and if you extend the compasses from the sine of 90 *gr.* vnto the tangent of 55 *gr.* 27 *m.* the same extent will reach from the sine of 15 *gr.* the complement of 75 *gr.* vnto the tangent of 20 *gr.* 36 *m.* and such is the angle C 9 B, made at the equator betweene the line B 9 drawne from the top of the style, and the houre-line C 9 drawne from the center. The like reason holdeth for the rest, which may be found and set downe in a table: then may you either draw these angles at *C* in the former figure more perfectly, and thence finish your worke, or else proceed

3 *To find the distance betweene the center and the parallels of declination.*

The distances betweene the center and the parallels of declination, may be found by resoluing the triangles made by the axis *BC*, the lines of declination, and the houre-lines. For hauing the angles at the equator, and knowing the declination of the parallell, if the parallell shall fall betweene the equator and the center, adde the declination vnto the angle at the equator; or if it shall fall without the equator, take the declination out of the angle at the equator, so shall you haue the angle at the parallell. Then

As the sine of the angle at the parallell,
to the cosine of the declination:
So the length of the axis of the style,
to the distance between the center and the parallell.

Thus in our example, the angle at the equator belonging to the houre of 4 after noone, was found before to be 51 *gr.* 30 *m*: if you would find the distance between the center and the equator, extend the compasses frō the sine of 51 *gr.* 30 *m.* vnto

vnto the ſine of *90 gr.* the complement of the declination, the ſame extent will reach in the line of numbers, from 12 vnto 15.33, and ſuch is the diſtance vpon the houre-line of 4 between the center and the equator.

If you would finde the diſtance vpon this houre-line, between the center and the inner tropique, whoſe declination is knowne to be 23 *gr.* 30 *m.* adde the declination to the angle at the equator, ſo the angle at the parallell wil be 75 *gr.* wherefore extend the compaſſes from the ſine of 75 *gr.* vnto the ſine of 66 *gr.* 30 *m.* the complement of the declination, the ſame extent will reach in the line of numbers, from 12 vnto 11.40, and ſuch is the length of the houre-line of 4 betweene the center and the tropique of ♑.

If you would finde the diſtance vpon this houre-line between this center and the tropique of ♋, which is here the fartheſt from the center, take the declination out of the angle at the equator, ſo the angle at the parallell will be 28 *gr.* wherefore extend the compaſſes from the ſine of 28 *gr.* vnto the ſine of 66 *gr.* 30 *m.* the ſame extent will reach in the line of numbers, from 12 vnto 23.44, and ſuch is the diſtance betweene the center and the tropique of ♋ vpon this houre-line of 4. The like reaſon holdeth for all the reſt, which may be gathered and ſet downe in a table.

That done and the equator drawne as before, if you would draw the tropique of ♋, looke into the table, and there finding vnder the title C ♋ the diſtance of the ſubſtylar between the center and the parallel of ♋ to be 20 inch. 80 *cent.* take 20 inch. 80 *cent.* out of the line of inches, and prick them downe in the ſubſtylar of your plane from C vnto ♋.

Or if either the center fall without your plane, or the extent be too large for your compaſſes, you may pricke downe the difference betweene C ♈ and C ♋. As here the diſtance C ♈ between the center & the equator is 14.57, the diſtance C ♋ 20.80, the differēce 6.23, therfore taking 6 inch. 23 *cent.* pricke them downe on the ſubſtylar from ♈ vnto ♋, and you ſhall haue the ſame interſection of the tropique and the ſubſtylar, as before; & the like reaſon holdeth for pricking down

of the rest of these distances on their seuerall houre-lines.

Then hauing the points of intersection betweene the houre-lines and the parallell, you may ioyne them all in a crooked line without making of any angles, the line so drawne shall be the tropique required. And after this maner may you draw any other parallell of declination, whereof you haue examples in the most of the former Diagrams.

CHAP. XIIII.

To describe the parallels of the Signes in any of the former Planes.

THe equator and the tropiques before described, do shew the Suns entrance into 4 of the Signes, the equator into ♈ and ♎, the one tropique into ♋, and the other into ♑, the rest of the intermediate Signes will be described in the same maner as the tropiques, if first we know their declination.

The maner of finding the declination not onely of the beginning of the Signes, but of all other points of the ecliptique, is before set downe in 2. *Prop. Astronomicall, pag.* 52. by which you may finde the declination of the beginning of ♉, ♍, ♏, and ♓ to be 11 *gr.* 30 *m.* and of ♊, ♌, ♐ and ♒ to be 20 *gr.* 12 *m.* If then you inscribe the chords of 11 *gr.* 30 *m.* and of 20 *gr.* 12 *m.* into the former figure *B D T Pag.* 145. from *D* toward *T*, the lines drawne from *B* through the termes of those chords shall be the Signes required.

And with these declinations, the height of the style, and the length of the axis, you may finde the angles at the parallell, and then the distances betweene the center and the parallell, which being pricked downe vpon their seuerall houre-lines shall giue you the points of intersection, by which you may draw the parallels of the Signes, as in the figures belonging to the polar planes.

CHAP.

CHAP. XV.

To describe the parallels of the length of the day in any of the former Planes.

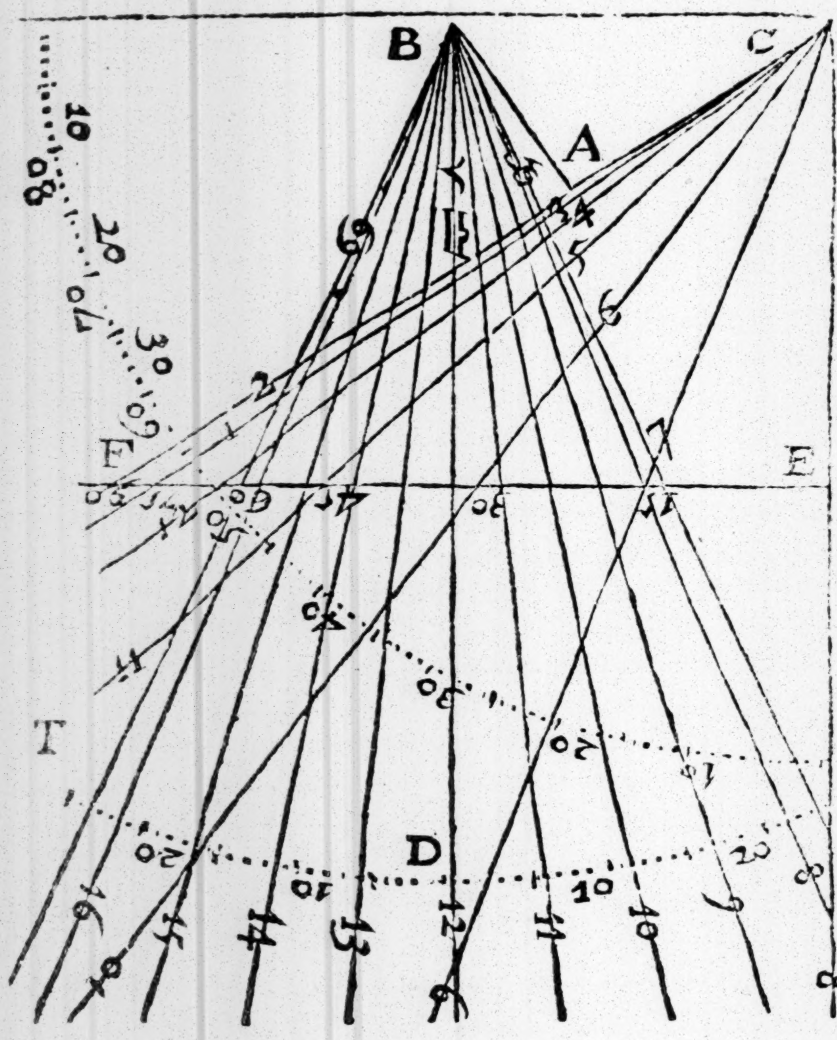
THe length of the day will alwayes be 12 houres long when the Sunne cometh to be in the equator, and this holdeth in all latitudes; but at other times of the yeare the same place of the Sunne, wil not giue the same length of the day in another latitude; wherefore the latitude being known, we are first

To find the declination of the Sunne agreeing to the length of the day.

Consider the difference betweene the length of an equinoctiall day and the day proposed, and turne the time into degrees and minutes.

As the sine of 90 *gr.*
is to the sine of halfe the difference:
So the cotangent of the latitude,
to the tangent of the declination.

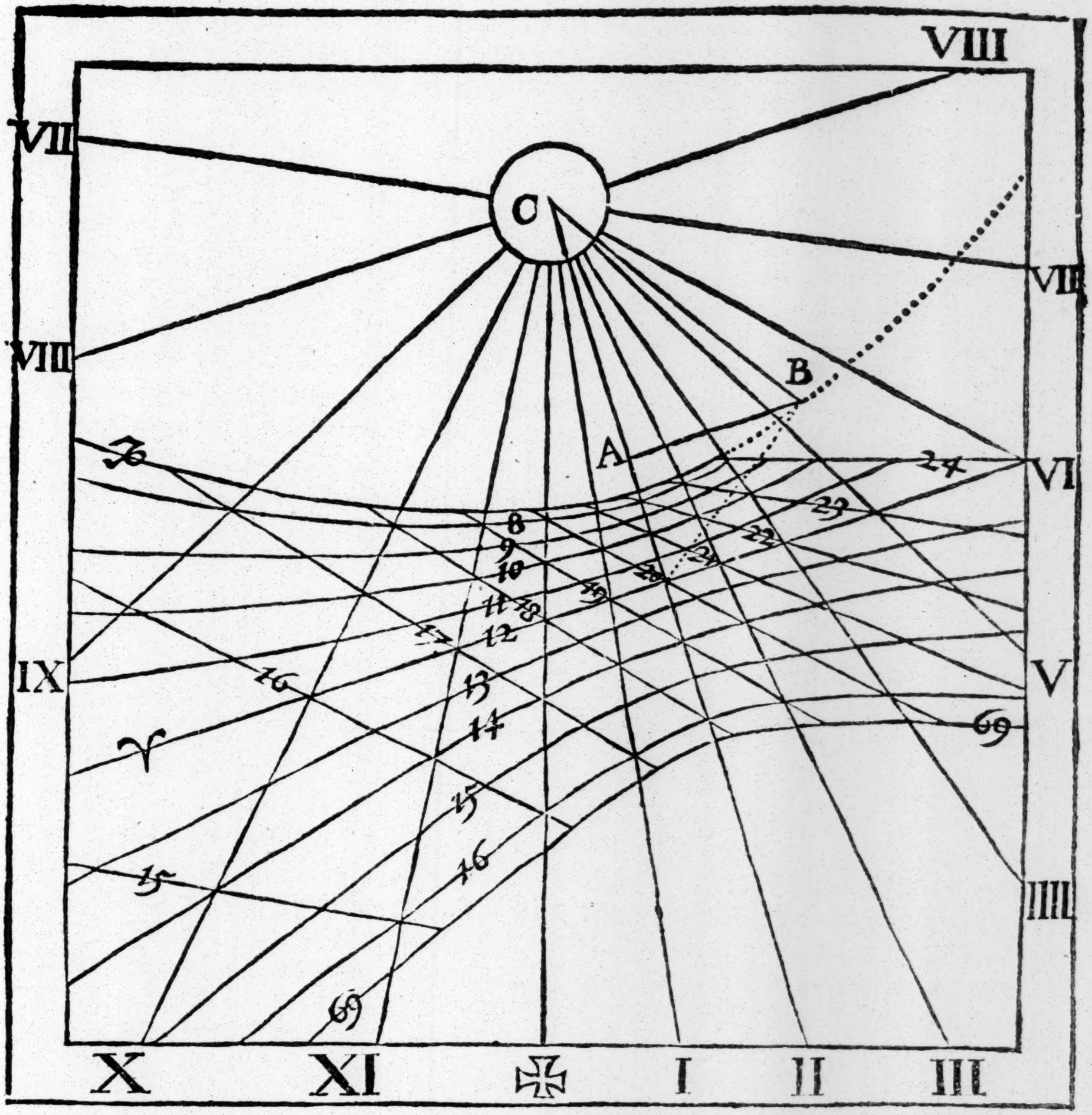
As if the length of the day proposed were 15 houres, the difference betweene this and an equinoctiall day (whose length is alwayes 12 houres) would be three houres, which make 45 *gr.* and the halfe difference is 22 *gr.* 30 *m:* wherefore extend the compasses from the sine of 90 *gr.* vnto the tangent of 38 *gr.* 30 *m.* the complement of the latitude, the same extent wil reach from the sine of 22 *gr.* 30 *m.* vnto the tangent of 16 *gr.* 55 *m.* for the declination of the Sunne at such time as the length of the day is either 9 or 15 houres; and from the sine of 30 *gr.* vnto the tangent of 21 *gr.* 40 *m.* for the declination belonging to 8 or 16 houres, and from the sine of



15 *gr.* vnto the tangent of 11 *gr.* 38 *m.* for the declination belonging to 10 or 14 houres, and from the sine of 7 *gr.* 30 *m.* vnto the tangent of 5 *gr.* 56 *m.* for the declination of the Sun when the length of the day is either 11 or 13 houres.

If then you inscribe the chords of these arks into the former figure *B D T*, the lines drawne from *B* through the termes of these arks, shall be the lines belonging to the diurnall arkes, and the seuerall distances betweene them and the point *C* giue the like distances betweene the center and the parallels of the length of the day vpon the houre-lines in your plane.

Or comparing these angles of declination with the angles at the equator, you may haue the angles at the parallell, and then find the distances between the center and the parallell, which being pricked downe vpon the seuerall houre-lines, shall

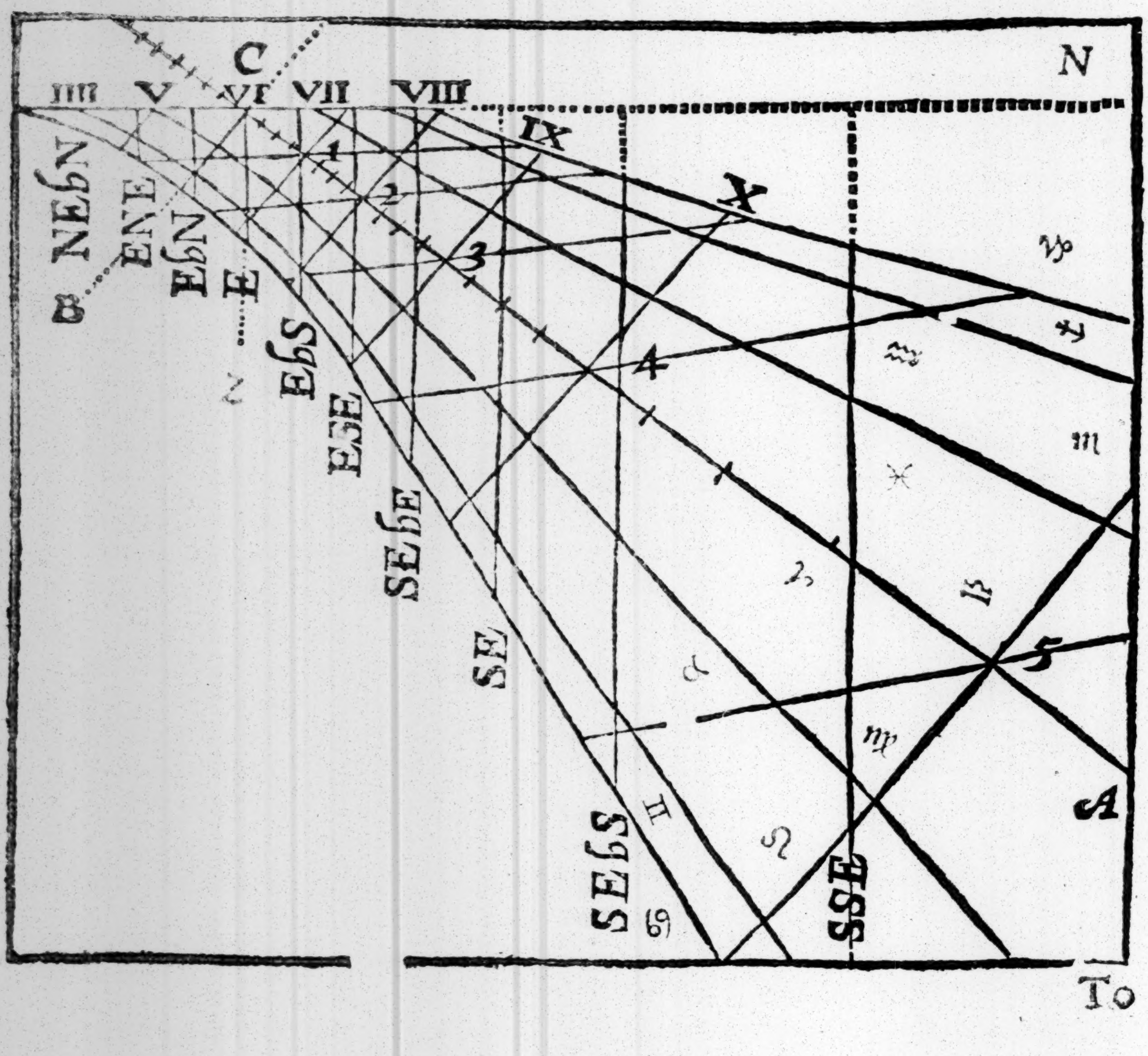


ſhall giue you the points of interſection, by which you may draw the parallels of the length of the day, whereof you haue another example in the diagram belonging to an horizontal plane, *pag.* 105. And by the ſame reaſon you may draw the parallels of thoſe circles to which the Sunne is verticall, the parallels of the principall feaſts, or what elſe depends on the declination of the Sunne.

CHAP. XVI.

To draw the old vnequall houres in the former Planes.

IT was the maner of the Ancients to divide the day into twelue equall houres, and the night into twelue other equal houres, and so the whole day and night into 24 houres. Of these 24, those which belonged vnto the day, were either longer or shorter (excepting the two equinoctial dayes) then those which belonged vnto the night; and the Summer houres alwayes longer then the houres in the Winter, according to the lengthening of the dayes, whereupon they are called the old vnequall (and by some the Planetary) houres.



To expresse these in the former Planes: first draw the common houre-lines, the equator, and the tropiques, as before: then describe two occult parallels of the length of the day, one for 9 houres, the other for 15 houres; for so you may draw a streight line for the first vnequall houre through 5 *ho.* 45 *m.* in the parallell of 15, and through 8 *ho.* 15 *m.* in the parallel of 9. This streight line shal passe directly through 7 *ho.* 0 *m.* in the equator, and so cut off a twelfth part of the arks aboue the horizon, both from these two parallels and the equator: and being continued vnto the tropiques, it shall also cut off about a twelfth part from them, and all the rest of the parallels of declination, without any sensible error.

In like maner may you draw the second vnequall houre through 7 *ho.* in the parallell of 15, through 8 *ho.* in the equator, and through 9 *ho.* in the parallell of 9, and so in the rest, as in this Table.

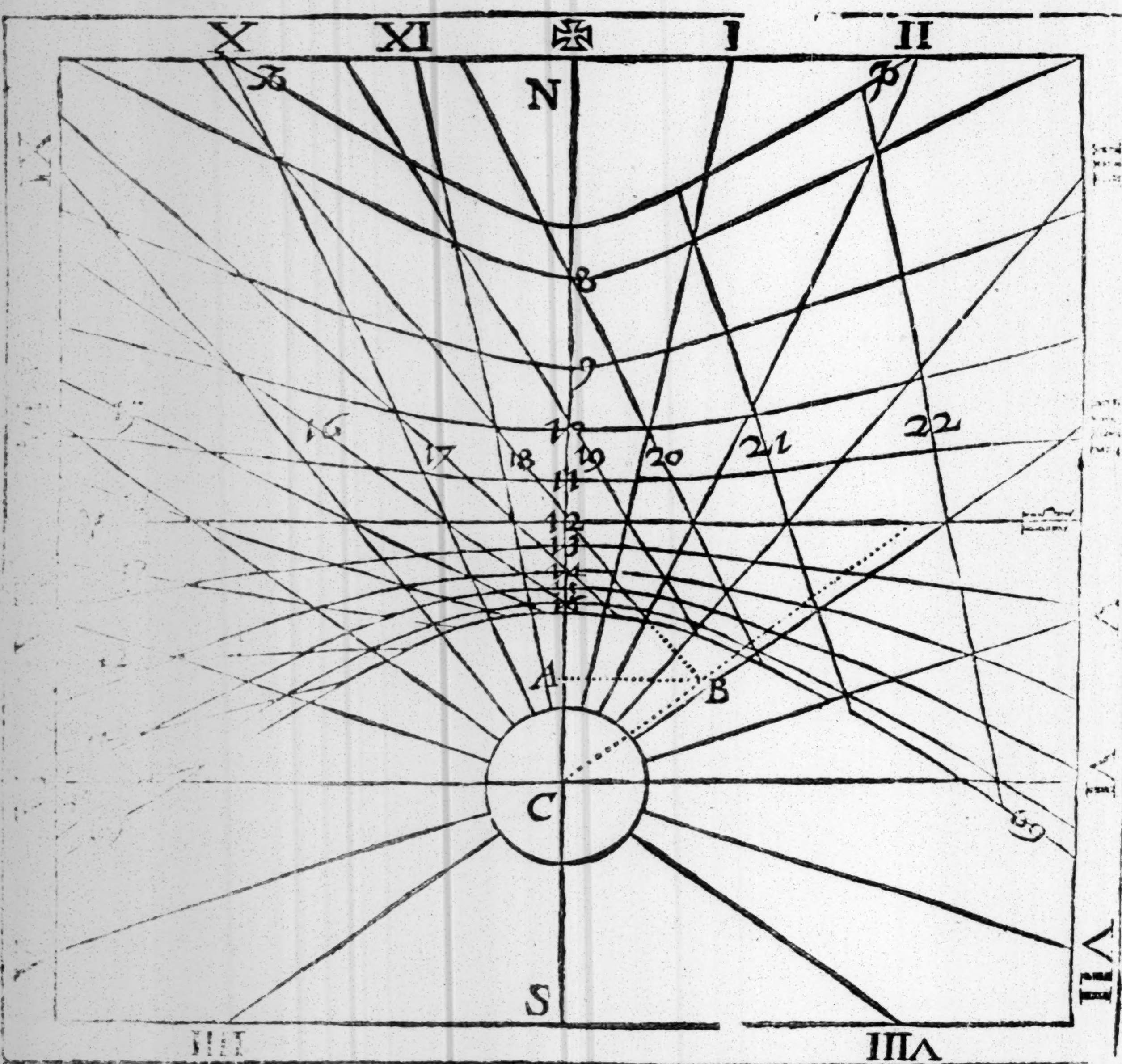
Hora	15		Æq	9	
	Ho.	M.	Ho	Ho.	M
0	4	30	6	7	30
1	5	45	7	8	15
2	7	0	8	9	0
3	8	15	9	9	45
4	9	30	10	10	30
5	10	45	11	11	15
6	12	0	12	12	0
7	1	15	1	0	45
8	2	30	2	1	30
9	3	45	3	2	15
10	5	0	4	3	0
11	6	15	5	3	45
12	7	30	6	4	30

And of these vnequall houres you haue a farther example in the diagram belonging to the polar declining plane, *Pag.* 130.

CHAP. XVII.

To draw the houres from Sun rising and sun setting in the former Planes.

TO know how many houres are past since the Sun rising, or how many remaine to the Sun setting; first draw the common houre-lines, the equator, and the tropiques, as before: then describe two occult parallels of the length of the day, one for 8 houres, and the other for 16 houres. For so you



may

may draw the first houre from the Sun rising through the common houres of 5 in the parallell of 16, of 7 in the equator, and of 9 in the parallell of 8. In like maner the second houre from Sun rising through the common houres of 6 in the parallell of 16, of 8 in the equator, and of 10 in the parallell of 8. And so the rest in their order.

The first houre before Sun setting, or the 23 houre from the last Sun setting, may be drawne in like sort through the common houres of 3 after noone in the parallell of 8, of 5 in the equator, and of 7 in the parallell of 16. The second houre before Sun setting, or the 22 houre after the last Sun setting through the common houres of 2 in the parallell of 8, of 4 in the equator, and of 6 in the parallell of 16. And so the rest in the like order, whereof you haue another example in the Diagram belonging to the declining verticall, *Pag.* 116.

CHAP. XVIII.

To draw the horizontall line in the former planes.

THe common houre-lines do commonly depend on the shadow of the axis, but the parallels of the Signes, and of the length of the day, the houre-lines from Sun rising and Sun setting, with many others, depend on the shadow of the top of the style, or some one point in the axis, which here signifieth the center of the world, and is represented by the point B. And these lines so depending, are then only vseful when they fall betweene the two tropiques, and within the horizon.

There may be seuerall horizontall lines drawne vpon euery plane, as I shewed before in finding the inclination of a plane; but the proper horizontall line which is here meant, must always be in the same plane with *B* the top of the style; so that in an horizontall plane there can be no such hori-

zontall line, but in all other planes it may be found by applying the horizontall leg of the *Sector* vnto the top of the style, and then working as before; and the intersection of this line with the meridian or substylar line, may be found by proportion.

1 *To find the intersection of the horizon with the meridian, in an equinoctiall plane.*

As the tangent of 45 *gr.*
to the tangent of the latitude:
So is the height of the style,
to the distance between the style and the horizontal line.

As in the example of the former equinoctiall plane, *Pag.* 142. extend the compasses from the tangent of 45 *gr.* vnto 51 *gr.* 30 *m.* the tangent of the latitude, the same extent will reach in the line of numbers, from 52 the length of the style vnto 66, and such is the distance betweene the style and the horizontall line; wherefore I take 66 parts out of a line of inches, and pricke them downe in the meridian line from *C* vnto *H* aboue the style in the vpper face, but below the style in the lower face of the plane, so a right line drawne through *H*, parallell to the houre of 6, shall be the horizontall line.

2 *To find the intersection of the horizon with the meridian, in a direct polar plane.*

As the tangent of 45 *gr.*
to the cotangent of the latitude:
So the length of the style,
to the distance between the style & the horizontal line.

As in the example of the former polar plane, *Pag.* 144. extend the compasses from the tangent of 45 *gr.* vnto tangent of 38 *gr.* 30 *m.* the complement of the latitude, the same extent will reach in the line of numbers, from 1.61 the length of

of the style, vnto 1.28, and such is the distance vpon the meridian betweene the style and the horizontall line.

In all vpright planes, whether they be direct verticall, or declining, or meridian planes, the horizontall line must alwayes be drawne through *A* the foot of the style, as may appeare in the examples before, *Pag.* 102. 107. 116.

And generally in all planes whatsoeuer, the horizontal line must be drawne through the intersection of the equator with the houre of 6. Or if that intersection fall without the plane, yet if any arks of the length of the day be drawne on the plane, the horizontall line may be drawne through their intersections, with the houres of the Suns rising or setting.

CHAP. XIX.

To describe the verticall circles in the former Planes.

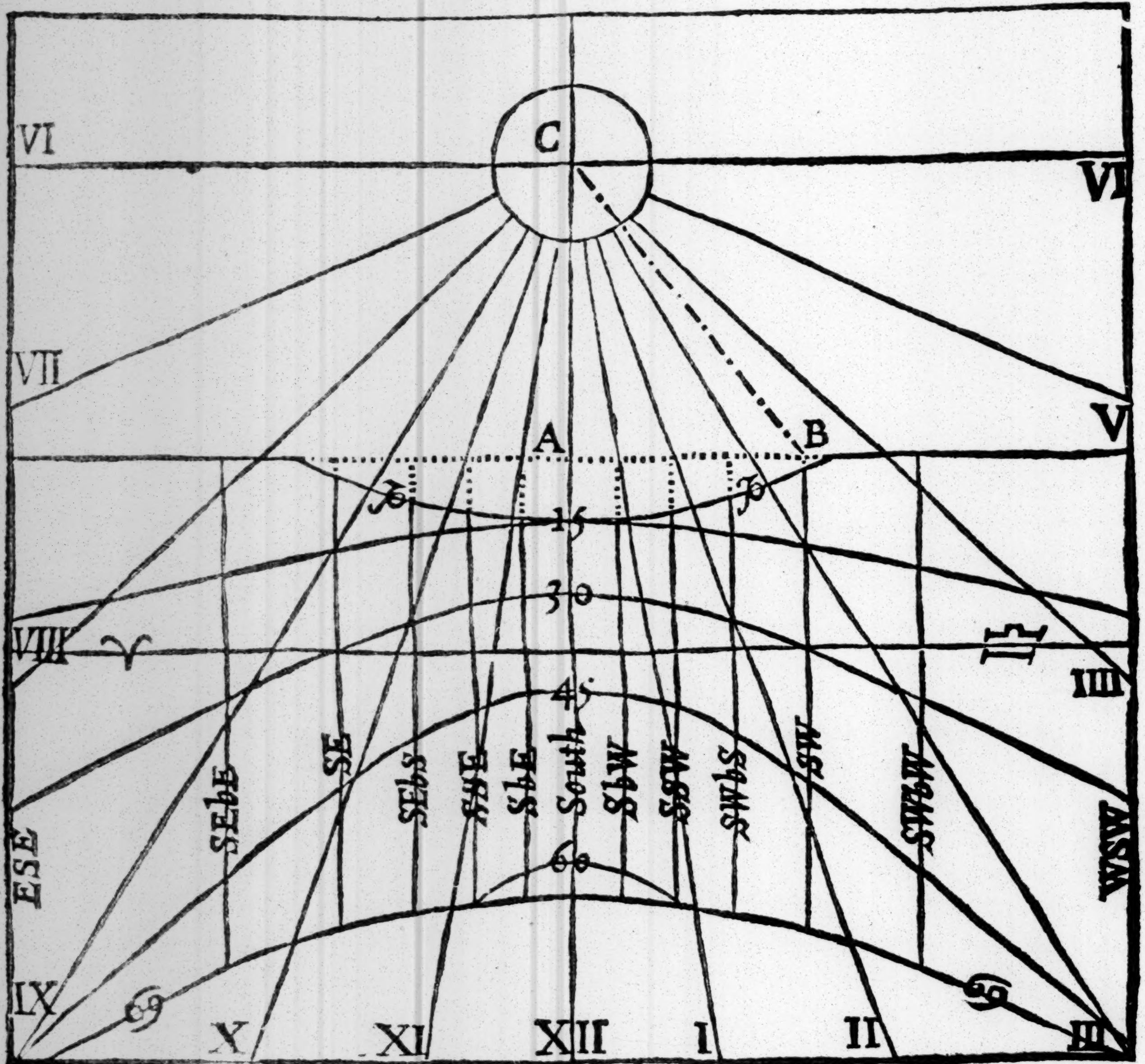
THe vertical circles commonly called Azimuths, are great circles drawne through the zenith, by which we may know in what part of the heauen the Sunne is, how far from the East or West, and how neare vnto the meridian.

In all vpright planes, whether they be direct verticals, or declining, or meridian planes, the semidiameter of the horizon wil be the same with *AB* the perpendicular side of the style, and these Azimuths will be parallels one to the other, and the distance of each Azimuth, from the foote of the style vpon the horizontall line, may be found in this manner.

Consider the length of the style in inches and parts of inches, and the distance of each Azimuth from the style, according to the angle at the zenith in degrees and minutes.

As the tangent of 45 *gr.*
to the tangent of the azimuth:

So the length of the ſtyle,
to the length of the horizontall line between the ſtyle and the azimuth.



As if it were required to draw the common azimuths on the South face of the verticall plane before deſcribed, where *AB* the length of the ſtyle may be ſuppoſed to be **10** inches. Here the plane hauing no declination, the ſtyle is in the plane of the meridian, and ſo pointeth directly into the South. The point of *S b E* is **11** *gr.* **15** *m.* diſtant from the ſtyle, and *S S E* **22** *gr.* **30** *m.* and the reſt in their order: wherefore extend the compaſſes from the tangent of **45** *gr.* vnto **10** in the line of numbers, the ſame extent will reach from the

tangent

tangent of 11 *gr.* 15 *m.* vnto 1.99 in the line of numbers for the length of the tangent line, betweene the style and the point *S b E*, and from the tangent of 22 *gr.* 30 *m.* vnto 4.14 for *S S E*, and so for the rest, as in this Table.

Azimuths.	An. Zen. Gr.	M.	Tangen In.	Pa.
South	0	0	0	0
S b E	11	15	1	99
S S E	22	30	4	14
SE b S	33	45	6	68
S E	45	0	10	00
SE b E	56	15	14	97
E S E	67	30	24	14
E b S	78	45	50	27
East	90	0	Infin.	

In like maner in the first example of the declining plane, where the style standeth according to the declination 24 *gr.* 20 *m.* distant from the South toward the West. The next point of *S b W* is but 13 *gr.* 5 *m.* distant from the style; and the second of *S S W* onely 1 *gr.* 50 *m.* and the third of *S W b S* is againe 9 *gr.* 25 *m.* and the rest in their order. Wherefore hauing before found the length of the style to be 6 inches 80 parts, extend the compasses from the tangent of 45 *gr.* vnto 6.80 parts in the line of numbers, the same extent wil reach from the tangent of 24 *gr.* 20 *m.* vnto 3.07 in the line of numbers for the length of the tangent line between the style & the South, and from the tangent of 13 *gr.* 5 *m.* vnto 1.58 for the point of *SbW*; and so for the rest, as in this Table.

Azimuths.	An. Zen. Gr.	M	Tangen In.	Pa.
SE b E	80	35	41	00
S E	69	20	18	03
SE b S	58	5	10	91
S S E	46	50	7	25
S b E	35	35	4	86
South	24	20	3	07
S b W	13	5	1	58
S S W	1	50	0	22
The foote of the styl				
SW b S	9	25	1	13
S W	20	40	2	57
SW b W	31	55	4	24
W S W	43	10	6	37
W b S	54	25	9	50
West	65	40	15	02
W b N	76	55	29	26
W N W	88	10	212	45

That done, if you take these parts out of a line of inches, and pricke them downe in the horizontall line on either side of the style, drawing right lines perpendicular to the horizon through these intersections, but so as they may be contained betweene the horizontall and the tropiques, the lines so drawne shall be the azimuths required.

In an horizontall plane these azimuths are drawne more easily. For here the perpendicular side of the style is the same with the axis of the horizon, and the foote of the style is the verticall point, in which all the azimuth lines doe meete as their circles do in the zenith: wherefore let any circle described on the center *A*, at the foote of the style, be diuided first into foure parts, beginning at the meridian, and then each quarter subdiuided either into eight equall parts, according to the points of the Mariners compasse, or into 90 *gr.* according to the Astronomicall diuision; if you draw right lines through the center and these diuisions, the lines so drawne shall be the azimuths required.

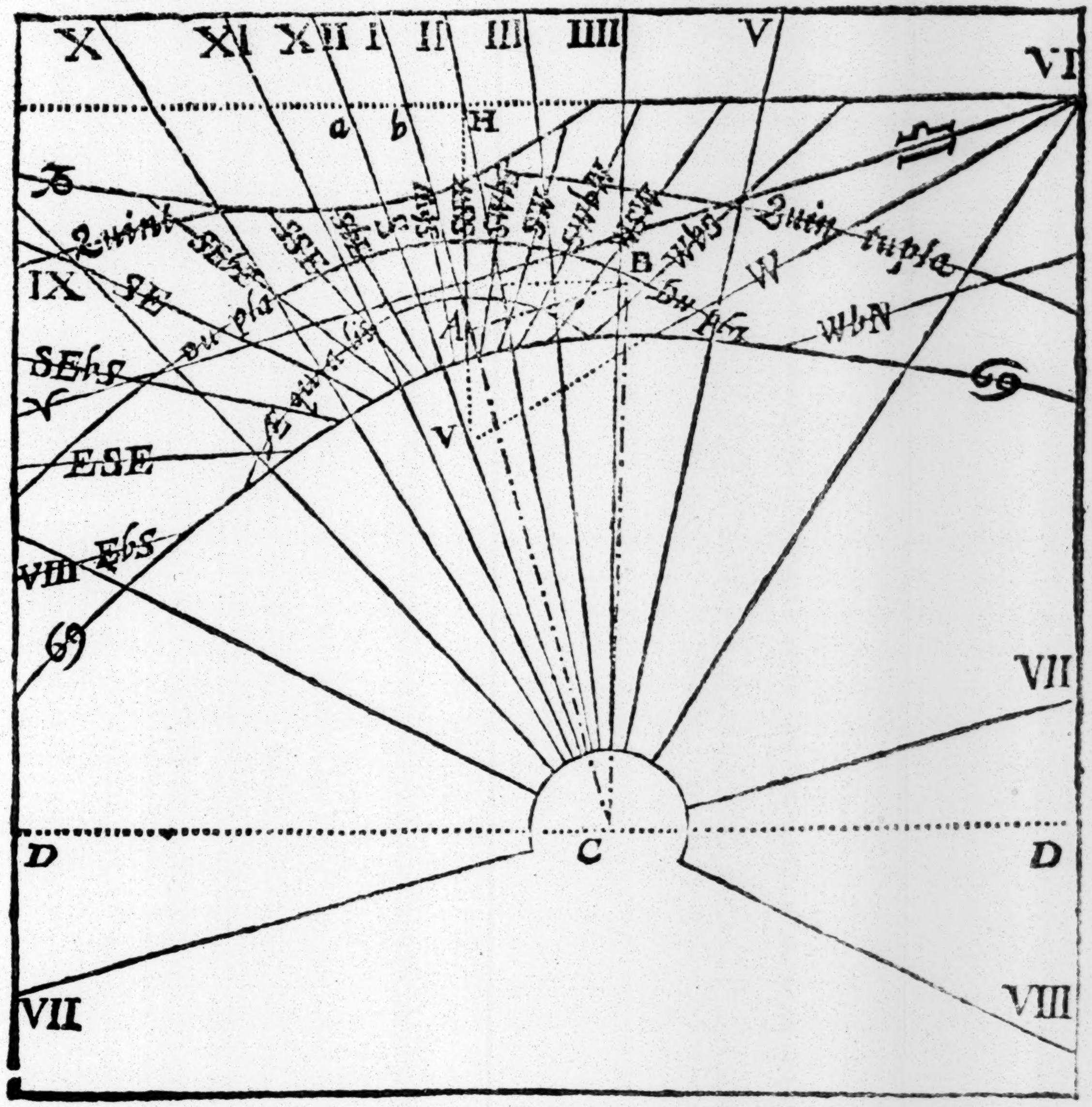
In all other planes inclining to the horizon, these vertical circles will meete in a point, but that verticall point being more or lesse distant from the foote of the style, the angles at this point will be vnequall.

1 *To find the distance between the foote of the style and the verticall point.*

The verticall point wherein all the verticall lines do meet, will be alwayes in the meridian, directly vnder or ouer the top of the style; and the angle betweene the perpendicular side of the style and the verticall line, will be equall to the inclination of the plane to the horizon. Wherefore

As the tangent of 45 *gr.*
to the tangent of the inclination of the plane:
so is the length of the style,
to the distance betweene the foote of the style and the verticall point.

Thus in the first exāple of the declining inclining planes, where the vpper face of the plane looking Southwest, the declination was 24 *gr.* 20 *m.* the inclination 36 *gr*; and you may suppose *AB* the length of the style to be 6 inches: if you extend the compasses from the tangent of 45 *gr.* vnto the



the tangent of 36 *gr.* the same extent will reach in the line of numbers from 6.00 vnto 4.36, for the distance *AV* betweene A the foote of the style and V the verticall point.

2 *To find the distance betweene the foote of the style and the horizontall line.*

As the tangent of the inclination of the plane,
is to the tangent of 45 *gr.*
So the length of the style,
to the distance betweene the foote of the style and the horizontall line.

So the same extent of the compasses as before, will reach in the line of numbers from 6.00 vnto 8.26 for the distance *AH*

betweene the foote of the style and the horizontall line.

Then may you take 4 inches 36 *cent.* and pricking them downe from *A* the foot of the style vnto *V* the verticall point in the meridian, draw the line *VA*, which being produced shall cut the horizon in the point *H* with right angles, and be that particular azimuth which is perpendicular to the plane.

Or you may take 8 inches 26 *cent.* and pricke them downe in the former line *VA* produced from *A* vnto *H*, and so draw the horizontall line through *H* perpendicular vnto *VH*, which horizontall line being produced wil crosse the equator in the same point wherein the equator crosseth the houre-line of 6, vnlesse there be some former error.

3 *To find the angles made by the azimuth lines at the verticall point.*

The angles at the zenith depend on the declination of the plane, as in our example, where the style standeth according to the declination 24 *gr.* 20 *m.* distant from the South toward the West, the azimuth of 10 *gr.* from the meridian Eastward will be 34 *gr.* 20 *m.* the azimuth of 10 *gr.* Westward will be onely 14 *gr.* 20 *m.* distant from the style, and so the rest in their order.

Or if you would rather describe the common azimuths, the point of *S b E* wil be 35 *gr.* 35 *m.* the point of *SbW* 13 *gr.* 5 *m.* distant from the style, and so the rest in their order. Then

> As the sine of 90 *gr.*
> to the cosine of the inclination of the plane:
> So the tangent of the angle at the zenith,
> to the tangent of the angle at the verticall point between the line drawne through the foot of the style and the azimuth required.

Wherefore the inclination of the plane in our example being 36 *gr.* extend the compasses from the sine of 90 *gr.* vn-

te

to the sine of 54 *gr.* the same extent shall reach in the line of tangents, from 24 *gr.* 20 *m.* vnto 20 *gr.* 5 *m.* for the angle *HVa* at ỹ vertical point, between the line *VH* drawne through *A* the foote of the style & the South. Againe, the same extent will reach from the tangent of 13 *gr.* 5 *m.* vnto 10 *gr.* 38 *m.* for the angle belonging to *S b W*; and so for the rest, as in this table.

Azimuths.	Ang. Ze. Gr.	M.	Ang. Ve. Gr.	M.
S E b E	80	35	78	25
S E	69	20	65	0
S E b S	58	5	52	25
S S E	45	50	40	46
S b E	35	35	30	3
South	24	20	20	5
S b W	13	5	10	39
S S W	1	50	1	29
	Style.		0	0
S W b S	9	25	7	38
S W	20	40	16	58
S W b W	31	55	26	45
W S W	43	10	37	11
W b S	54	25	48	30
West	65	40	60	48
W b N	76	55	73	58
W N W	88	10	87	44

These angles being knowne, if on the center *V*, at the verticall point, you describe an occult circle, and therein inscribe the chords of these angles from the line *VH*, and then draw right lines through the verticall point, and the termes of those chords, the lines so drawne shall be the azimuths required.

The like reason holdeth for the drawing of the azimuths vpon all other inclining planes, wheof you haue another example in the Diagram belonging to the meridian incliner. *Pag.* 126.

Or for further satisfaction you may finde where each azimuth line shall crosse the equator.

As the sine of 90 *gr.*
to the sine of the latitude:
So the tangent of the azimuth from the meridian
to the tangent of the equator from the meridian.

Extend the compasses from the sine of 90 *gr.* vnto the sine of our latitude 51 *gr.* 30 *m.* the same extent will reach in the line of tangents from 10 *gr.* vnto 7 *gr.* 50 *m.* for the intersection of the equator with the azimuth of 10 *gr.* from the meridian. Againe, the same extent will reach from 20 *gr.*

vnto 15 *gr.* 54 *m.* for the azimuth of 20 *gr.* And so the rest, as in these tables.

Azim. Gr.	M.	*Equat.* Gr.	M.
10	0	7	50
20	0	15	54
30	0	24	20
40	0	43	18
50	0	13	0
60	0	53	35
70	0	65	3
80	0	77	18
90	0	90	0

Azim. Gr.	M.	*Equat.* Gr.	M.
11	15	8	51
22	30	17	58
33	45	27	36
45	0	38	2
56	15	49	30
67	30	62	6
78	45	75	44
90	0	90	0

By which you may see that the azimuth 90 *gr.* distant from the meridian, which is the line of East and West, will crosse the equator at 90 *gr.* from the meridian in the same point, with the horizontall line and the houre of 6. And that the azimuth of 45 *gr.* will crosse the equator at 38 *gr.* 2 *m.* from the meridian, that is, the line of *S E* will crosse the equator at the houre of 9 and 28 *m.* in the morning, and the line of *S W* at 2 *ho.* 32 *min.* in the afternoone; and so for the rest, whereby you may examine your former worke.

CHAP. XX.

To describe the parallels of the horizon in the former planes.

THe parallels of the horizon, commonly called Almicanters, or parallels of altitude (whereby we may know the altitude of the Sunne aboue the horizon) haue such respect vnto the horizon, as the parallels of declination vnto the equator, and so may be described in like maner.

In

In an horizontall plane, these parallels will be perfect circles; wherefore knowing the length of the style in inches and parts, and the distance of the parallell from the horizon in degrees and minutes.

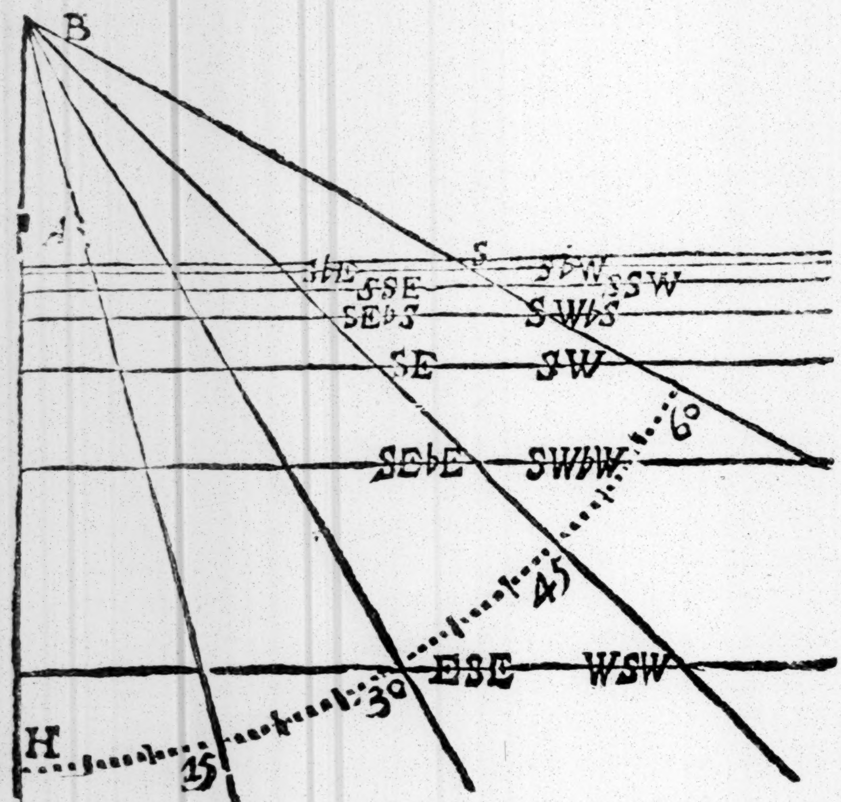
As the tangent of 45 *gr.*
is to the length of the style:
So the cotangent of the parallell,
to the semidiameter of his circle.

Thus in the example of the horizontall plane, *Pag.* 164. if *A B* the length of the style shall be 5 inches, and that it were required to finde the semidiameter of the parallell of 62 *gr.* extend the compasses from the tangent of 45 *gr.* vnto 5.00 in the line of numbers, the same extent will reach from the tangent of 28 *gr.* the complement of the parallell vnto 2.65, and if you describe a circle on the center *A* to the semidiameter of 2 inches 65 *cent.* it shall be the parallell required.

In all vpright planes, whether they be direct verticals, or declining, or meridian planes, these parallels will be conicall sections, and may be drawne through their points of intersection, with the azimuth lines, in the same maner as the parallels of declination, through their points of intersection with the houre-lines. To this end you may first finde the distance betweene the top of the style and the azimuth; and then the distance betweene the horizon and the parallell, both which may be represented in this maner.

On the center *B* and any semidiameter *B H*, describe an occult arke of a circle, and therein inscribe the chords of such parallels of altitude as you intend to draw on the plane, (I haue here put them for 15.30.45 and 60 *gr.*) then draw right lines through the center and the termes of those chords, so the line *B H* shall be the horizon, and the rest the lines of altitude, according to their distance from the horizon.

Than

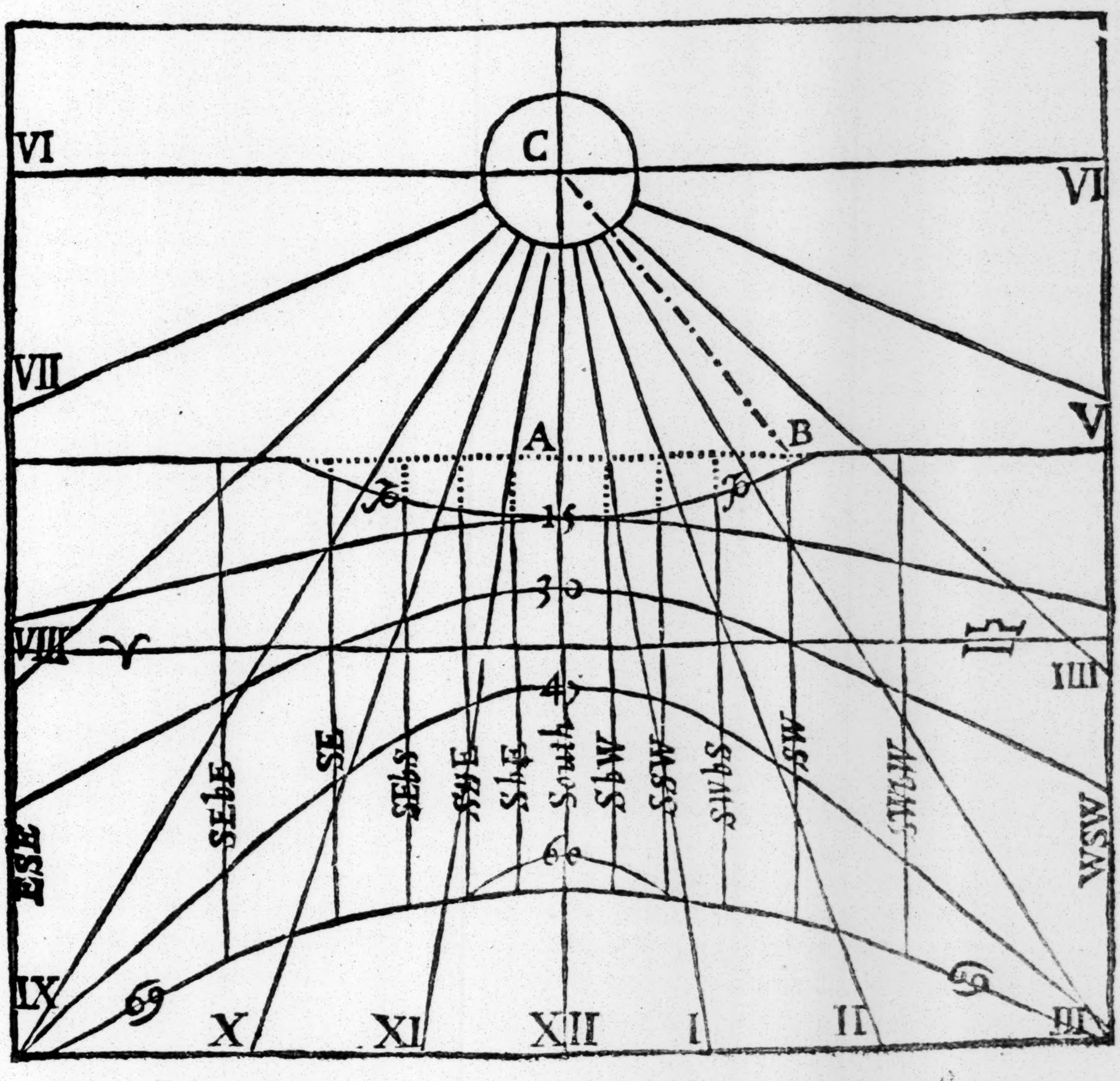


That done, consider your plane (which here for example is the South face of our vertical plane, *p.* 168) wherein hauing drawne both the horizontall & verticall lines, as I shewed before, first take out *A B* the length of the style, & pricke that downe in this horizontall line from *B* vnto *A*; then take out all the distances between *B* the top of the style and the seuerall points wherein the verticall lines do crosse the horizontal, transfer them into this horizontal line BH, from the center *B*, and at the terms of these distances erect lines perpendicular to the horizon, noting them with the number or letter of the azimuth, from whence they were taken, so these perpendiculars shall represent those azimuths, and the seuerall distances betweene the horizon and the lines of altitude shall giue the like distances, betweene the horizontall and the parallels of altitude vpon the azimuths in your plane. Vpon this ground it followeth.

1 ***To find the distance between the top of the style, and the seuerall points wherein the azimuths do crosse the horizontall line.***

Hauing drawne the horizontall and azimuth lines as before, looke into the table by which you drew them, and there you shall haue the angles at the zenith. Then

As the cosine of the angle at the zenith,
  is to the sine of *90 gr.*
So the length of the style,
  to the distance required.



Azimuths.	Ang Ze Gr.	M	Tangent Inch	P.	Secant Inch.	P.	Par. 15. Inch.	P.	Par. 20. Inch.	P
South.	0	0	0	0	10	00	2	68	5	77
S b E	11	15	1	99	10	20	2	73	5	90
S S E	22	30	4	14	10	82	2	90	6	24
S E b S	33	45	6	68	12	03	3	23	6	94
S E	45	0	10	00	14	14	3	80	8	16
S E b E	56	15	14	97	18	00	4	82	10	40
E S E	67	30	24	14	26	13	7	02	15	08
E b S	78	45	50	27	51	26	13	73	29	60
East.	90	0	Infinit		Infinit		Infinit		Infinit	

As in our example of the verticall plane, where *A B* the length of the style was supposed to be 10 inches, extend the compasses from the sine of 78 *gr.* 45 *m.* (the complement of 11 *gr.* 15 *m.* the angle at the zenith, belonging to *S b E* and *S b W*) vnto the sine of 90 *gr.* the same extent wil reach from 10.00 the length of the style, vnto 10.20 for the distance betweene the top of the style and the intersection of the azimuth *S b E* with the horizontall line, which distance may be called the *secant* of the azimuth, and may serue for the drawing of the parallell of 45 *gr.* from the horizon. The like reason holdeth for the rest of these distances here represented in the line B H.

2 *To finde the distance betweene the horizon and the parallels.*

As the tangent of 45 *gr.*
to the tangent of the parallell:
So the secant of the azimuth,
to the distance required.

As if it were required to draw the parallell of 15 *gr.* from the horizon, vpon this verticall plane; extend the compasses from the tangent of 45 *gr.* vnto the tangent of 15 *gr.* the same extent will reach in the line of numbers from 10.00 the secant

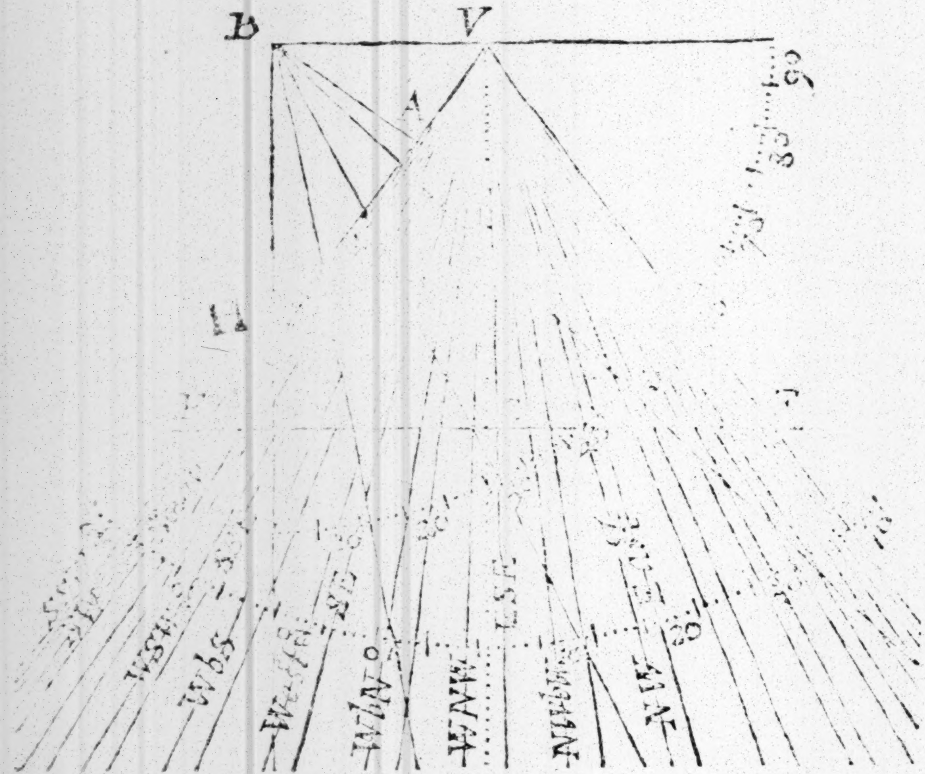
cant of the South azimuth vnto 2.68, and therefore the distance betweene the horizon and the parallell of 15 *gr.* is 2 inches 68 *cent.* vpon the South azimuth. Againe, the same extent will reach from 10.20 the secant of *S b E* vnto 2.73 for the like distance belonging to *S b E* and *S b W*; and so for the rest, which may be gathered and set downe in the table.

That done, and the horizon and azimuths being drawne, pricke downe 10 inches from the horizontall line vpon the South azimuth, & 10 inches 20 *cent.* on the azimuths of *SbE* and *SbW*, and 10 inches 82 *cent.* on the azimuths of *SSE* and *SSW*, and 12 inches 3 *cent.* on the azimuth of *SEbS* and *SWbS*, and so the rest of these distances on their seuerall azimuths: then if you draw a crooked line through all these points, that may make no angles, the line so drawne shall be the parallell of 45 *gr.* from the horizon. In like maner may you draw the parallell of 15 *gr.* or any other parallell of altitude vpon any verticall plane.

If the plane incline to the horizon, after we haue found the verticall point, and drawne the horizontall line, we are farther to finde the length of the axis of the horizon, then the angles betwixt this axis and the azimuth lines, and so the seuerall distances betweene the parallels and the verticall point, all which may be represented in this manner.

On the center *B*, and any semidiameter, describe an occult quadrant of a circle, and therein inscribe the chords of such parallels of altitude as you intend to draw on the plane, drawing right lines through the center and the termes of these chords, so the line B H shall be the horizon, and his perpendicular *B V* the axis of the horizon, and the rest the lines of altitude, according to their distance from the horizon.

That done, consider your plane, which here for example is the first of our three declining inclining planes, wherein hauing drawne both the horizontall and verticall lines as I shewed before, first take out the axis of the horizon, which



the line between B the top of the ſtyle and V the verticall point, and pricke that downe in this figure from *B* vnto *I*; then take out both the line *VH* and all the reſt of the diſtances between V the verticall point and the ſeuerall points wherein the verticall lines doe croſſe the horizontall line of this figure, from the point *V*, noting the place where they croſſe the horizontall line with the number or letter of the azimuth from whence they were taken, and drawing the azimuth lines from *V* through the lines of altitude.

Or hauing the *Sector* you may draw an occult line *VE* perpendicular to the axis *VB*, and therein prick downe the tangent of the complement of the inclination of the plane from *V* vnto *E*: then draw the line *EF* parallell to the axis, croſſing the line *VH* produced in the point *F*, ſo this line *EF* will be as the line of ſines vpon the *Sector*, and therein you may pricke downe the ſines of the complement of the angles at the zenith from *E* towards *F*, and draw the verticall lines by thoſe points through the lines of altitude, ſo the angles at V, betweene the axis V B and thoſe azimuth lines, ſhall be the angles betweene the axis of the horizon and the

azimuth

azimuth lines on your plane, and the seuerall distances betweene the point V and the lines of altitude, shall giue the like distances betweene the verticall point and the parallels of altitude vpon the azimuths in your plane. Vpon this ground it followeth,

1 *To find the length of the axis of the horizon.*

The verticall point is alwayes either directly ouer or vnder the top of the style, and the distance betweene them is that which I call the axis of the horizon, which may thus be found,

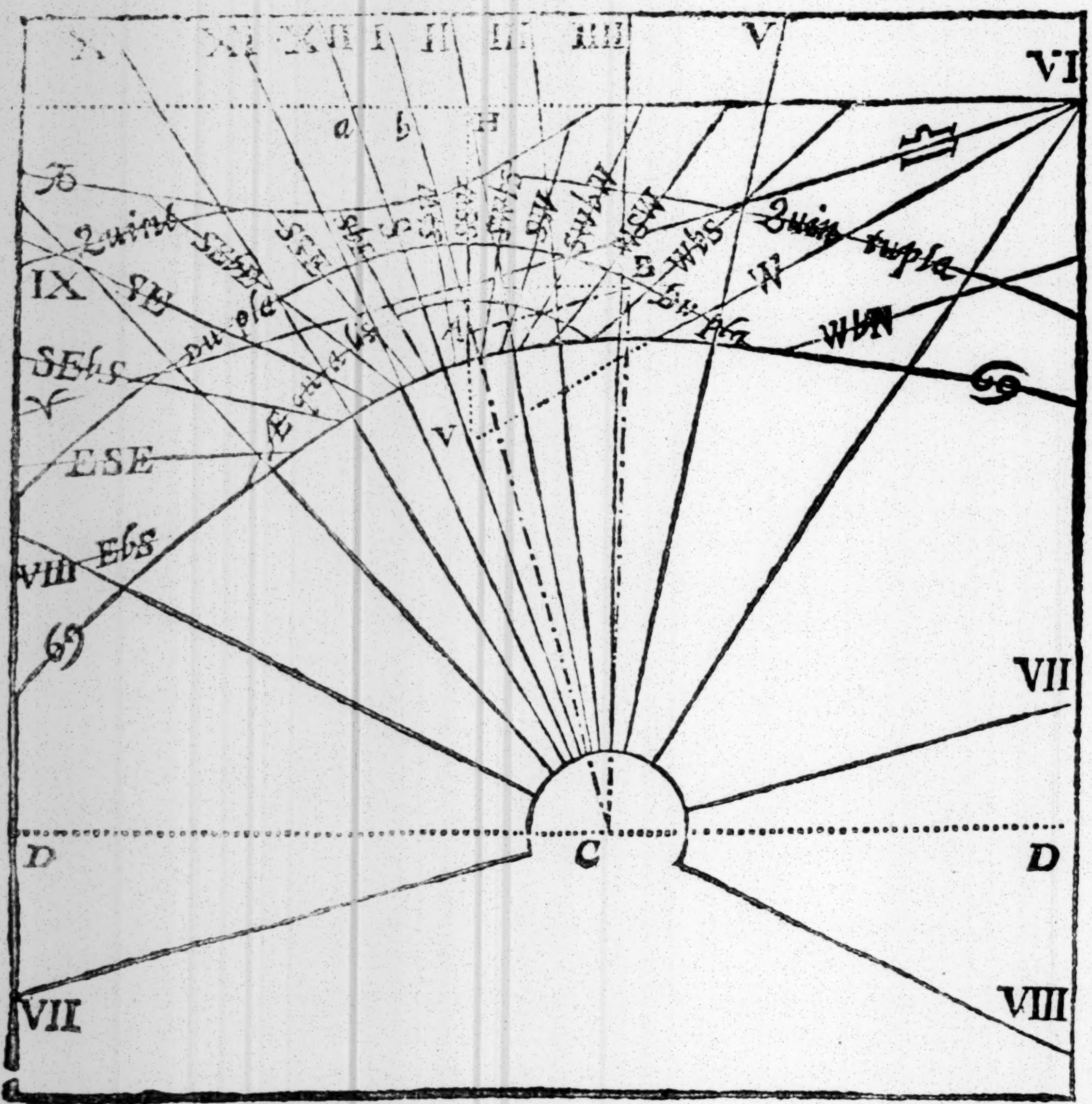
As the cosine of the inclination,
to the sine of *90 gr.*
So the length of the style,
to the length of the axis of the horizon.

For example in the first of the three declining inclining planes, the inclination to the horizon is 36 *gr.* the length of the style *A B* six inches, extend the compasses from the sine of 54 *gr.* the complement of the inclination vnto the sine of 90 *gr.* the same extent wil reach in the line of numbers from 6.00 vnto 7.42, & such is VB the length of the axis required.

2 *To find the angles contained betweene the horizon and the verticall lines vpon your plane.*

The angles at the vertical point betweene the axis of the horizon and the azimuth lines vpon your plane are represented in this figure by those at V, betweene V B and the azimuths. The angles betweene the horizon and the azimuth lines being complements to the former, are represented either by those which are made by V E or by E H, and the azimuth lines which are drawne from V.

That you may find them, looke into the Table, by which you drew the azimuth lines, there shall you finde the angles at the zenith. Then



As the sine of *90 gr.*
to the cosine of the angle at the zenith:
So the tangent of the inclination to the horizon,
to the tangent of the angle betweene the horizon
and the verticall line.

In our example where the inclination to the horizon is *36 gr.* and the angle at the zenith betweene the azimuth at the style and the meridian, is according to the declination *24 gr. 20 m.* extend the compasses from the sine of *90 gr.* unto the tangent of *36 gr.* the same extent wil reach from the sine of *65 gr. 40 m.* the complement of the angle at the zenith, unto the tangent of *33 gr. 30 m.* for the angle contained be-
tween

tween the horizon and the South part of the meridian line. Again, the ſame extent wil reach frō the coſine of 35 *gr.* 35 *m.* the angle at the zenith belonging to *S b E* vnto the tangent of 30 *gr.* 3 *m.* for the angle betweene the horizon and the azimuth line of *S b E.* The like reaſon holdeth for the reſt, which may be found and ſet downe in the Table.

Azimuths.	Ang. Ze. Gr.	M.	Ang. V. Gr.	M.	Ang. Ho Gr.	M.	Horizon Inch.	P.	11 18 Inch.	P	20 34 Inch	P.	45 0 Inch.	P.
East.	114	25	119	12	16	40	In-				38	60	11	05
E *b* S	103	5	106	2	19	20	fi-		210	24	22	40	9	00
E S E	91	50	92	16	1	20	nite.		41	98	15	57	7	60
SE *b* E	80	35	78	25	6	47	62	82	23	44	12	07	6	68
S E	69	20	65	0	14	23	29	87	16	79	10	12	6	00
S E *b* S	58	5	52	25	21	0	20	70	13	61	8	99	5	79
S S E	46	50	40	46	26	25	16	68	11	90	8	31	5	53
S b E	35	35	30	3	30	35	14	58	10	90	7	90	5	42
South	24	20	20	5	33	30	13	44	10	32	7	66	5	35
S b W	13	5	10	39	35	17	12	84	10	02	7	55	5	33
S S W	1	50	1	29	35	59	12	62	9	90	7	47	5	31
	Style.		0	0	36	0	12	62	9	90	7	47	5	31
SWbS	9	25	7	38	35	37	12	74	9	96	7	50	5	32
SW	20	40	16	58	34	12	13	20	10	20	7	59	5	34
SWbW	31	55	26	45	31	40	14	13	10	67	7	81	5	39
WSW	43	10	37	11	27	55	15	85	11	50	8	15	5	49
W b S	54	25	48	30	22	55	19	05	12	94	8	73	5	66
West	65	40	60	48	16	40	25	87	15	51	9	60	5	96
W*bN*	76	55	73	58	9	20	45	75	20	64	11	32	6	46
W N *W*	88	10	87	44	1	20	318	88	33	27	14	18	7	25
NWbW	99	25	101	35	6	47	Infi-		92	40	19	60	8	48
N W	110	40	115	0	14	23	nit.				31	44	10	30

Then may you either draw theſe angles at V in the former figure more perfectly, and thence finiſh your worke, or elſe proceed.

3 *To find the diſtance between the verticall point and the parallels of the horizon.*

Theſe diſtances may be found by reſoluing the triangles in the laſt figure made by the axis, the lines of altitude, and the azimuth lines. For hauing the length of the axis and the angles at the horizon, if you adde the diſtance of the parallel from the horizon vnto the angle at the horizon, you ſhall haue the angle at the parallell. Then

As the ſine of the angle at the parallell,
to the coſine of the altitude:
So the length of the axis,
to the diſtance betweene the verticall point and the parallell.

Thus in our example if it were required to finde the diſtance vpon the ſtylar azimuth V H, betweene the verticall point and the horizon, you haue the rectangle triangle V BH, wherein the angle at the horizon here repreſented by BHV (equall to the inclination of the plane) 36 *gr.* and B V the axis of the horizon betweene the plane and the top of the ſtyle, is 7 inches 42 *cent.* Wherefore extend the compaſſes from the ſine of 36 *gr.* vnto the ſine of 90 *gr.* the complement of the altitude, the ſame extent will reach in the line of numbers from 7.42 vnto 12 62, and ſuch is the diſtance of the perpendicular azimuth line V H between the verticall point and the horizon.

In like maner if you would find the diſtance vpon the meridian betweene the verticall point and the horizon, extend the compaſſes from the ſine of 33 *gr.* 30 *m.* the angle at the horizon, to the ſine of 90 *gr.* the ſame extent will reach in the line of numbers from 7.42 vnto 13.44, and ſuch is *Va* the diſtance betweene the verticall point and the horizon vpon the line of the South azimuth, that is, vpon the meridian line.

But

But if you would find the distance vpon the meridian betweene the verticall point and any other parallell of the horizon, as vpon the parallell of *26 gr. 34 m.* then adde these *26 gr. 34 m.* vnto *33 gr. 30 m.* the angle at the horizon, so shall you haue *60 gr. 4 m.* for BDV the angle at the parallell. And if you extend the compasses from the sine of *60 gr. 4 m.* vnto the sine of *63 gr. 26 m.* the complement of the parallell from the horizon, the same extent will reach in the line of numbers from 7.42 the length of the axis, vnto 7.66, and such is the distance VD between the verticall point and the parallel of *26 gr. 34 m.* vpõ the meridian line. The like reason holdeth for all the rest, which may be gathered & set down in ỳ table.

That done, and the horizon drawne as before, if you would draw the parallel of *26 gr. 34 m.* from the horizon, looke into the table, and there finding vnder the title of the parallel of 26.34, the distance on ỳ South azimuth line to be 7.66, take 7 inches *66 cent.* out of a line of inches, and prick them down on the meridian of your plane, from the verticall point at *V.*

Or if either the verticall point fall without your plane, or the extent at any time be too large for your compasses, you may pricke downe the distance betweene the horizon and the parallel. As here the distance betweene the vertical point and the parallell is 7.66, betweene the verticall point and the horizon 13.44, the difference between them 5.78 is the distance frõ the horizon to the parallel, which being pricked downe vpon the meridian, shall giue the same intersection as before. And the like reason holdeth for the pricking down the rest of these distances on their seuerall azimuths.

Hauing the points of intersection betweene the azimuths and the parallell, you may ioyne them all in a crooked line without making of angles, the line so drawne shall be the parallell required. And vpon this ground it followeth,

To describe such parallels on the former planes, as may shew the proportion of the shadow vnto the gnomon.

The proportion of a mans shadow vnto his height, or o-

ther shadow to his gnomon set perpendicular to the horizon, may be shewed by parallels to the horizon, if they be drawne to a due altitude, which may thus be found:

As the length of the shadow, to the length of the gnomon:
So the tangent of 45 *gr.* to the tangent of the altitude.

As if it were required to finde the altitude of the Sunne when the shadow of a man shall be decuple to his height, extend the compasses from 10 vnto 1 in the line of numbers, the same extent will reach in the tangent of 45 *gr.* vnto the tangent of 5 *gr.* 42 *m*; which shewes that when the Sun commeth to the altitude of 5 *gr.* 42 *m.* your shadow, vpon a leuell ground, will be ten times as much as your height. In the same maner you may finde that at 7 *gr.* 7 *m.* of altitude your shadow wil be octuple, at 9 *gr.* 27 *m.* sextuple, at 11 *gr.* 18 *m.* quintuple, at 14 *gr.* 2 *m.* quadruple, at 18 *gr.* 26 *m.* triple, at 26 *gr.* 34 *m.* double to your height, at 33 *gr.* 41 *m.* as 3 vnto 2, at 36 *gr.* 52 *m.* as 4 vnto 3, at 38 *gr.* 40 *m.* as 5 vnto 4, at 45 *gr.* equall, at 51 *gr.* 20 *m.* as 4 vnto 5, at 53 *gr.* 7 *m.* as 3 vnto 4, at 56 *gr.* 19 *m.* as 2 vnto 3, at 59 *gr.* 2 *m.* as 3 vnto 5, at 63 *gr.* 26 *m.* as 1 vnto 2, &c.

If then you draw a parallell to the horizon at 5 *gr.* 42 *m.* another at 7 *gr.* 7 *m.* and so the rest, when the shadow of the style falleth on the parallell, you haue the proportion, and thereby may you know the shadow by the height, and the height by the shadow, whereof you haue examples pag. 136. and 137.

I might here proceed to shew the description of the circles of position, the Signes of the Zodiacke in the meridian, the Signes ascending and descending, with such other gnomonicall conclusions; but these would proue superfluous to such as vnderstand the doctrine of the Sphere; and for others, that which is deliuered may suffise for ordinary vse, it being my intention not so much to explane the full vse of shadowes (whereof I haue lately giuen a large example in an other place) as the vse of these lines of proportion, that were not extant heretofore.

An Appendix concerning

The description and vse of a small portable Quadrant, for the more easie finding of the houre and Azimuth.

CHAP. I.

Of the description of the Quadrant.

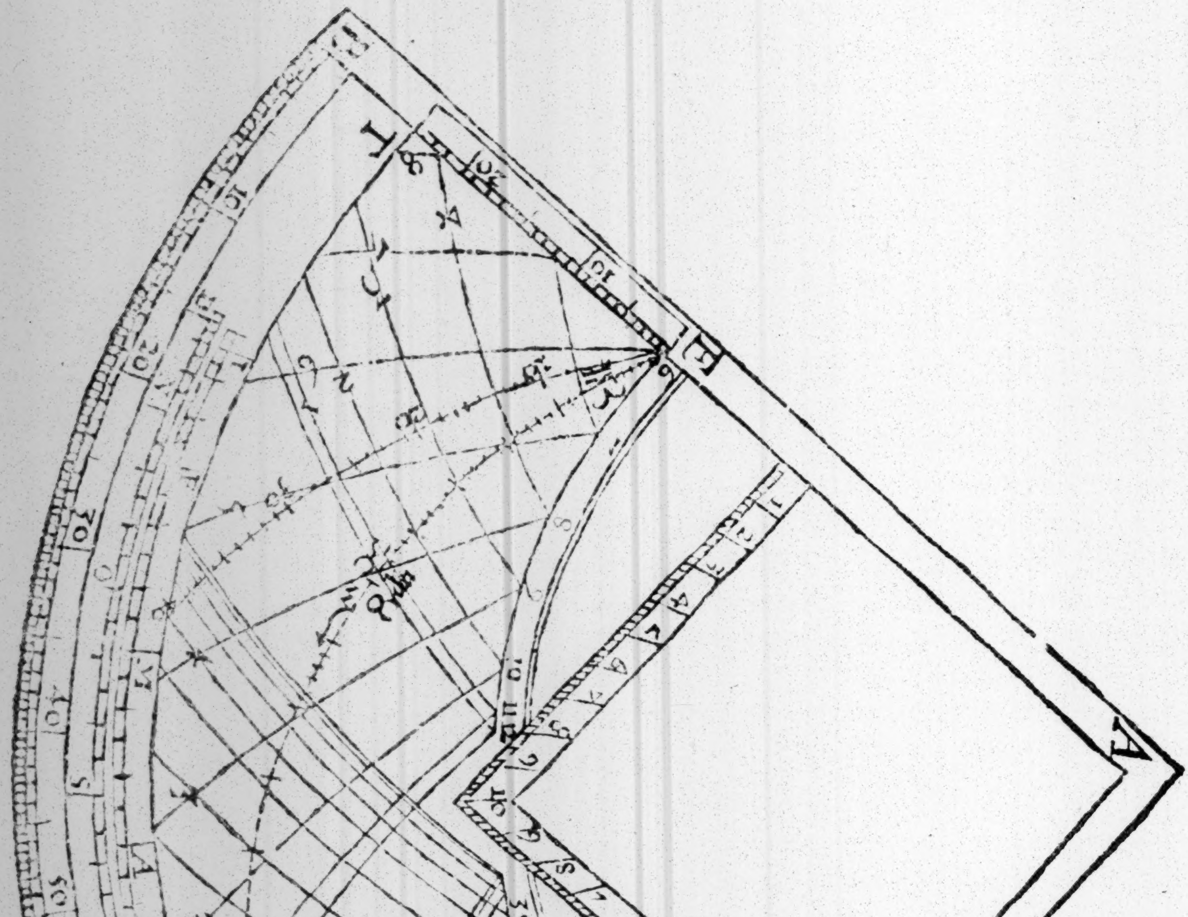
HAuing described these standing planes, I will now shew the most of these conclusions by a small Quadrant. This might be done generally for all latitudes, by a quarter of the generall Astrolabe, described before in the vse of the *Sector*, *pag.*58; and particularly for any one latitude, by a quarter of the particular Astrolabe, there allso described, *pag.*63. which if it be a foote semidiameter, may shew the azimuth vnto a degree, and the time of the day vnto a minute; but for ordinary vse this smaller Quadrant may suffice, which may be made portable in this maner.

1 Vpon the center *A*, and semidiameter *AB*, describe the arke *BC*: the same semidiameter will set of 60 *gr.* and the halfe of that will be 30 *gr.* which being added to the former 60 *gr.* will make the arke *BC* to be 90 *gr.* the fourth part of the whole circle, and thence comes the name of a Quadrant.

2 Leauing some little space for the inscription of the moneths and dayes, on the same center *A*, and semidiameter *AT*, describe the arke *TD*, which shall serue for either tropique.

3 Diuide the line *AT* in the point *E*, in such proportion, as that *AT* being 10000, *AE* may be 6556, and there draw another arke *EF*, which shall serue for the Equator.

4 Diuide *AF* the semidiameter of the equator in the point *G*, so as *AF* being 10000, the line *AG* may be 4343, and



and on the center *G* and semidiameter *G D* describe the arke *ED*, which shall serue for a fourth part of the ecliptique.

5 This part of the ecliptique may be diuided into three

Signes,

Signes, and each Signe into 30 *gr.* by a table of right aſcenſions, made as before *pag.60.* As the right aſcenſion of the firſt point of ♉ being 27 *gr.*54 *m.* you may lay a ruler to the center *A* & 27 *gr.*54 *m.* in the Quadrant *BC*, the point where the ruler croſſeth the Ecliptique, ſhall be the firſt point of ♉. In like maner the right aſcenſion of the firſt point of ♊ being 57 *gr.*48 *m.* if you lay a ruler to the center *A*, and 57 *gr.* 48 *m.* in the quadrant, the point where the ruler croſſeth the ecliptique, ſhalbe the firſt point of ♊. And ſo for the reſt: but the lines of diſtinction between Signe & Signe, may be beſt drawne from the center *G*.

A Table of right Aſcenſions.

Gr.	♈ Gr.	♈ M.	♉ Gr.	♉ M.	♊ Gr.	♊ M.
0	0	0	27	54	57	48
5	4	35	32	42	63	3
10	9	11	37	35	68	21
15	13	48	42	31	73	43
20	18	27	47	33	79	7
25	23	9	52	38	84	32
30	27	54	57	48	90	0

6 The line *E T* betweene the equator and the tropique, which I call the line of declination, may be diuided into 23 *gr.* ½ out of this Table. For let *A E* the ſemidiameter of the equator be 10000, the diſtance betweene the equator and 10 *gr.* of declination may be 1917 more; between the equator and 20 *gr.* 4281; the diſtance of the tropique from the equator 5252.

7 You may put in the moſt of the principall ſtarres betweene the equator and the tropique of ♋, by their declination from the equator, and right aſcention from the next equinoctial point. As the declination of the *wing of Pegaſus*, being 13 *gr.*7 *m.* the right aſcenſion 358 *gr.*34 *m.* from the firſt point of ♈, or 1 *gr.*26 *m.* ſhort of it. If you draw an occult parallell through 13 *gr.*7 *m.* of declination, and then lay the ruler to the center *A*, and 1 *gr.*26 *m.* in the quadrant *BC*, the point where the ruler croſſeth the parallell ſhall be the place for the *wing of Pegaſus*, to which you may

Gr.	Parts.
1	176
2	355
3	537
4	723
5	913
6	1106
7	1302
8	1503
9	1708
10	1917
11	2130
12	2348
13	2571
14	2799
15	3032
16	3270
17	3514
18	3763
19	4019
20	4281
21	4550
22	4825
23	5108
Tro	5252

set the name and the time when he cometh to the South, in this maner, *W.Peg.* * 23 **Ho.** 54 *M.* and so for the rest of these fiue, or any other starres.

		Ho.	M.	R. Ascen		Decl.	M.	
Pegasus wing	*	23	54	1	26	13	7	
Arcturus	*	13	58	29	37	21	10	14 : 02
Lions heart	*	9	48	32	58	13	45	9 : 54
Buls eye	*	4	15	63	33	15	42	4 : 18
Vultures heart	*	19	23	66	56	7	58	19 : 34

8 There being space sufficient between the equator and the center, you may there describe the quadrat, and diuide each of the two sides farthest frõ the center *A* into 100 parts, so shall the Quadrant be prepared generally for any latitude.

But before you draw the particular lines, you are to fit foure tables vnto your latitude.

First a table of meridian altitudes for diuision of the circle of dayes and monethes, which may be thus made: Consider the latitude of the place and the declination of the Sun for each day of the yeare. If the latitude and declination be alike both North or both South, ad the declinatiõ to the complement of the latitude; if they be vnlike, one North, and the other South, substract the declination from the complement of the latitude, the remainder will be the meridian altitude belonging vnto the day.

Thus in our latitude of 51 *gr.* 30 *m.* Northward, whose complement is 38 *gr.* 30 *m.* the declination vpon the tenth day of Iune will be 23 *gr.* 30 *m.* Northward, wherefore I adde 23 *gr.* 30 *m.* vnto 38 *gr.* 30 *m.* the summe of both is 62 *gr.* for the meridian altitude at the tenth of Iune. The declination vpon the tenth of December will be 23 *gr.* 30 *m.* Southward, wherefore I take these 23 *gr.* 30 *m.* out of 38 *gr.* 30 *m.* there wil remain 15 *gr.* for the meridian altitude at the tenth of December; and in this maner you may find the meridian altitude for each day of the yeare, and set them downe in a table.

The

Dies. / Mo.	0		5		10		15		20		25		30	
	Gr.	M	Gr.	M.	Gr.	M	Gr.	M.	Gr.	M	Gr.	M	Gr.	M.
Ianuary	16	31	17	24	18	26	19	37	20	57	22	24	23	58
February	24	17	25	59	27	45	29	35	31	29	33	25		
March	34	35	36	33	38	32	40	30	42	27	44	22	46	15
April	46	37	48	26	50	11	51	50	53	25	54	53	56	15
May	56	15	57	29	58	35	59	33	60	22	61	2	61	31
Iune	61	36	61	54	62	0	61	58	61	45	61	22	60	49
Iuly	60	49	60	6	59	14	58	13	57	4	55	48	54	24
August	54	7	52	36	50	59	49	17	47	31	45	41	43	49
September	43	26	41	30	39	33	37	36	35	38	33	41	31	46
October	31	46	29	53	28	3	26	16	24	35	22	59	21	29
Nouember	21	12	19	51	18	39	17	36	16	43	16	0	15	28
December	15	28	15	7	15	0	15	2	15	17	15	44	16	22

The Table being made, you may inſcribe the moneths, and dayes of each moneth into your quadrant, in the ſpace left below the tropique. For lay the ruler vnto the center *A*, and **16** *gr.* **31** *m.* in the quadrant *BC*, there may you draw a line for the end of December and beginning of Ianuary; then laying your ruler to the center *A*, and **24** *gr.* **17** *m.* in the quadrant, there draw the end of Ianuary and beginning of Febr[illegible], and ſo the reſt, which may be noted with *I, F, M, A, M,* [illegible] the firſt letters of each moneth, and wil here fall [illegible] 15 *gr.* and 62 *gr.*

[illegible] Table which you are to fit, may ſerue for the [illegible] and diuiding of the horizon. For drawing of the horizon

As the cotangent of the latitude,
  to the tangent of the greateſt declination:
So the ſine of 90 *gr.*
  to the ſine of interſection, where the horizon ſhall croſſe the tropiques.

So in our latitude of 51 *gr.* 30 *m.* we ſhall find the horizon to cut the tropique in 33 *gr.* 9 *m:* wherefore if you lay the ru-

36°28′ = Lat. 53°50′

ler

ler to the center *A*, and 33 *gr.* 9 *m.* in the quadrant, the point where the ruler crosseth the tropique shall be the point where the horizon crosseth the tropique. And if you finde a point at *H*, in the line *AC*, whereon setting the compasses, you may bring the point at *E*, and this point in the tropique both into a circle, the point *H* shall be the center, and the ark so drawne shall be the horizon. Then for the diuision of this horizon.

As the sine of 90 *gr.*
to the sine of the latitude:
So the tangent of the horizon,
to the tangent of the arke in the quadrant, which shall diuide the horizon.

53°. 50′. 8°. 6′

So in our latitude of 51 *gr.* 30 *m.* we shall finde 7 *gr.* 52 *m.* belonging to 10 *gr.* in the horizon, and 15 *gr.* 54 *m.* belonging to 20 *gr.* And so the rest, as in this Table.

Ho	Gr.	M	Ho	Gr.	M	Ho	Gr.	M.	Ho	Gr.	M.	Ho	Gr.	M.	Ho	Gr.	M.
0	0	0	15	11	51	30	24	19	45	38	2	60	53	35	75	71	5
	0	47		12	39		25	11		39	1		54	41		72	19
	1	34		13	27		26	4		40	0		55	48		73	33
	2	21		14	16		26	57		41	0		56	56		74	48
	3	8		15	4		27	50		42	0		58	4		76	3
5	3	55	20	15	54	35	28	43	50	43	0	65	59	13	80	77	18
	4	42		16	43		29	37		44	1		60	22		78	33
	5	29		17	33		30	32		45	3		61	31		79	49
	6	17		18	22		31	27		46	5		62	41		81	5
	7	4		19	12		32	22		47	8		62	52		82	21
10	7	52	25	20	2	40	33	18	55	48	11	70	65	3	85	83	37
	8	39		20	53		34	14		49	14		66	15		84	53
	9	27		21	44		35	10		50	19		67	27		86	10
	10	14		22	36		36	7		51	24		68	39		87	26
	11	2		23	27		37	4		52	29		69	52		88	43
15	11	51	30	24	19	45	38	2	60	53	35	75	71	5	90	90	0

Where-

Wherefore you may lay the ruler to the center *A*, and 7 *gr.* 52 *m.* in the quadrant *B C*, the point where the ruler crosseth the horizon shall be 10 *gr.* in the horizon; and so for the rest: but the lines of distinction between each fift degree, will be best drawne from the center *H.*

The third Table for drawing of the houre-lines, must be a Table of the altitude of the Sunne aboue the horizon at euery houre, especially when he cometh to the equator, the tropiques, and some other intermediate declinations.

If the Sunne be in the equator, and so haue no declination.

As the sine of 90 *gr.*
to the cosine of the latitude:
So the cosine of the houre from the meridian,
to the sine of the altitude.

Thus in our latitude of 51 *gr.* 30 *m.* at six houres from the meridian the Sunne wil haue no altitude, at fiue the altitude will be 9 *gr.* 17 *m*; at foure 18 *gr.* 8 *m*; at three 26 *gr.* 7 *m*; at two 32 *gr.* 37 *m.* at one 36 *gr.* 58 *m*; at noone it will be 38 *gr.* 30 *m.* equall to the complement of the latitude.

If the Sunne haue declination, the meridian altitude wil be found as before, for the Table of dayes and moneths.

If the houre proposed be six in the morning or six at night.

As the sine of 90 *gr.*
to the sine of the latitude:
So the sine of the declination,
to the sine of the altitude.

Thus in our latitude the declination of the Sunne being 23 *gr.* 30 *m.* the altitude will be found to be 18 *gr.* 11 *m*: the declination being 11 *gr.* 30 *m.* the altitude will be 9 *gr.*

If the houre proposed be neither twelue nor six.

As the cosine of the houre from the meridiau,
to the sine of 90 *gr.*

So the tangent of the latitude,
to the tangent of a fourth arke.

So in our latitude and one houre from the meridian, this fourth ark will be found to be 52 *gr.* 28 *m.* at two 55 *gr.* 26 *m.* at three 60 *gr.* 39 *m.* at foure 68 *gr.* 22 *m.* and at fiue houres from the meridian 78 *gr.* 22 *m.*

Then consider the declination of the Sunne and the houre proposed; if the latitude and declination be both alike, as with vs in North latitude, North declination, and the houre fall between noone and six, take the declination out of the fourth arke, the remainer shall be your fift arke.

But if either the houre fall between six and midnight, or the latitude and declination shall be vnlike, adde the declination vnto the fourth arke, and the summe of both shall be your fifth arke: or if the summe shall exceed 90 *gr.* you may take the complement vnto 180 *gr.* This fifth arke being knowne:

As the sine of the fourth arke,
to the sine of the latitude:
So the cosine of the fift arke,
to the sine of the altitude.

Thus in our latitude of 51 *gr.* 30 *m.* Northward, the Sunne hauing 23 *gr.* 30 *m.* of North declination, if it shall be required to finde the altitude of the Sunne for seuen in the morning; here because the latitude and declination are both alike to the Northward, and the houre proposed falleth betweene noone and six, you may take 23 *gr.* 30 *m.* the arke of the declination out of 78 *gr.* 22 *m.* the fourth arke belonging to the fift houre from the meridian, so there will remaine 54 *gr.* 52 *m.* for your fift arke. Then working according to the Canon, you shall find,

As the sine of 78 *gr.* 22 *m.* your fourth arke,
to the sine of 51 *gr.* 30 *m.* for the latitude:

So

So the sine of 35 *gr.* 8 *m.* the cōplement of your fift ark,
to the sine of 27 *gr.* 17 *m.* the altitude required.

If in the same latitude and declination, it were required to finde the altitude for fiue in the morning, here the houre falling betweene six and midnight; if you adde 23 *gr.* 30 *m.* vnto 78 *gr.* 22 *m.* the summe will be 101 *gr.* 52 *m.* and the complement to 180 *gr.* will be 78 *gr.* 8 *m.* for your fifth arke. Wherefore

As the sine of 78 *gr.* 22 *m.*
to the sine of 51 *gr.* 30 *m.*
So the cosine of 78 *gr.* 8 *m.*
to the sine of 9 *gr.* 32 *m.* for the altitude required.

If in the same latitude of 51 *gr.* 30 *m.* Northward, the Sunne hauing 23 *gr.* 30 *m.* of South declination, it were required the altitude for nine in the morning; here because the latitude and declination are vnlike, the one North, and the other South, you may adde 23 *gr.* 30 *m.* the arke of declination, vnto 60 *gr.* 39 *m.* the fourth arke belonging to the third houre from the meridian, so shall you haue 84 *gr.* 9 *m.* for your fift arke. Wherefore

As the sine of 60 *gr.* 39 *m.*
to the sine of 51 *gr.* 30 *m.*
So the cosine of 84 *gr.* 9 *m.*
to the sine of 5 *gr.* 15 *m.* for the altitude required.

And so by one or other of these meanes you may finde the altitude of the Sunne for any point of the ecliptique at all houres of the day, and set them downe in such a Table as this.

A Table for the altitude of the Sunne in the beginning of each Signe at all houres of the day, calculated for 51 gr.30 m. of North latitude.

Ho.		♋ Gr.	M.	♊ ♌ Gr.	M.	♉ ♍ Gr.	M.	♈ ♎ Gr.	M.	♓ ♏ Gr.	M.	♒ ♐ Gr.	M.	♑ Gr.	M.
12		62	0	58	42	50	0	38	30	27	0	18	18	15	0
11	1	59	43	56	34	48	12	36	58	25	40	17	6	13	52
10	2	53	45	50	55	43	12	32	37	21	51	13	38	10	30
9	3	45	42	43	6	36	0	26	7	15	58	8	12	5	15
8	4	36	41	34	13	27	31	18	8	8	33	1	15		
7	5	27	17	24	56	18	18	9	17	0	6				
6	6	18	11	15	40	9	0	0	0						
5	7	9	32	6	50									11	37
4	8	1	32											21	40

Laſtly, you may finde what declination the Sunne hath when he riſeth or ſetteth at any houre.

As the ſine of 90 *gr.*
to the ſine of the houre from ſix:
So the cotangent of the latitude,
to the tangent of the declination.

And ſo in the latitude of 51 *gr.*30 *m.* you ſhall finde that when the Sun riſeth, either at fiue in the Summer, or ſeuen in the Winter, his declination is 11 *gr.*37 *m:* when he riſeth at foure in the Summer, or eight in the Winter, his declination is 21 *gr.*40 *m.* which may be alſo ſet downe in the Table.

That done, you may there ſee that in this latitude the meridian altitude of the Sunne in the beginning of ♋ is 62 *gr.* in ♊ 58 *gr.*42 *m.* in ♉ 50 *gr.* in ♈ 38 *gr.*30 *m.* &c. But the beginning of ♋ and ♑ is repreſented by the tropiques *T D*, drawne at 23 *gr.*30 *m.* of declination, and the beginning of ♈ and ♎ by the equator *E F.* If you draw an occult parallell betweene the equator and the tropique, at 11 *gr.*30 *m.* of declination,

clination, it ſhall repreſent the beginning of ♉,♍,♏,and ♓; if you draw another occult parallell though 20 *gr.* 12 *m* of declination,it ſhall repreſent the beginning of ♊,♌,♐,and ♒.

Then you may lay a ruler to the center *A*,and 62 *gr.* in the quadrant *BC*, and note the point where it croſſeth the tropique of ♋; then moue the ruler to 58 *gr.* 52 *m.* and note where it croſſeth the parallell of ♊; then to 50 *gr.* and note where it croſſeth the parallell of ♉;and againe to 38 *gr.* 30 *m.* noting where it croſſeth the equator; ſo the line drawne through theſe points ſhall ſhew the houre of 12 in the Summer,while the Sunne is in ♈,♉,♊,♋,♌,or ♍. In like maner if you lay the ruler to the center *A*, and 27 *gr.* in the quadrant,and note the point where it croſſeth the parallel of ♓, then moue it to 18 *gr.* 18 *m.* and note where it croſſeth the parallell of ♒; and againe to 15 *gr.* noting where it croſſeth the tropique of ♑; the line drawne through theſe points ſhall ſhew the houre of 12 in the Winter,while the Sunne is in ♎, ♏, ♐, ♑, ♒ & ♓, and ſo may you draw the reſt of theſe houre-lines: onely that of 7 from the meridian in the Summer, and 5 in the Winter, will croſſe the line of declination at 11 *gr.* 37 *m.* and that of 8 in the Summer, and 4 in the Winter at 21 *gr.* 40 *m.*

The fourth table for drawing of the azimuth lines, muſt likewiſe be fitted for the altitude of the Sunne aboue the horizon at euery azimuth,eſpecially when he cometh to the equator, the tropiques, and ſome other intermediat declinations.

If the Sunne be in the equator, and ſo haue no declination:

As the ſine of 90 *gr.*
to the coſine of the azimuth from the meridian:
So the cotangent of the latitude,
to the tangent of the altitude at the equator.

Thus in our latitude of 51 *gr.* 30 *m.* at 90 *gr.* from the meridian, the Sunne will haue no altitude;at 80 *gr.* the altitude

will be 7 *gr.*52 *m*; at 70 *gr.* it will be 15 *gr.*30 *m*; at 60 *gr.* it will be 21 *gr.*41 *m.*

If the Sunne haue declination, the meridian altitude will be easily found as before, for the table for dayes and moneths. And for all other azimuths.

As the sine of the latitude,
to the sine of the declination:
So the cosine of the altitude at the equator,
to the sine of a fourth arke.

When the latitude and declination are both alike in all azimuths from the prime verticall vnto the meridian, adde this fourth arke vnto the arke of altitude at the equator.

When the latitude and declination are both alike, and the azimuth more then 90 *gr.* distant from the meridian, take the altitude at the equator out of this fourth arke.

When the latitude and declination are vnlike, take this fourth arke out of the arke of altitude at the equator, so shall you haue the altitude of the Sunne belonging to the azimuth.

Thus in our latitude of 51 *gr.*30 *m.* Northward, if it were required to finde the altitude of the Sunne in the azimuth of 60 *gr.* from the meridian, when the declination is 23 *gr.* 30 *m.* Nothward, you may finde the altitude at the equator belonging to this azimuth to be 21 *gr.*41 *m.* by the former Canon, and by this last Canon you may finde the fourth arke to be 28 *gr.*15 *m.* Then because the latitude and declination are both alike to the Northward, if you adde them both together, you shall haue 49 *gr.*56 *m.* for the altitude required.

If the declination had been 23 *gr.*30 *m.* to the Southward, you should then haue taken this fourth ark out of the ark at the equator, which because it cannot here be done, it is a signe that the Sunne is not then aboue the horizon. But if you take the arke at the equator out of this fourth arke, you shall haue 6 *gr.*34 *m.* for the altitude of the Sunne when he is in

in the azimuth of 60 *gr.* from the North, and 120 *gr.* from the South part of the meridian. The like reason holdeth for the rest of these altitudes, which may be gathered and set downe in a table.

Lastly when the Sun riseth or setteth upon any azimuth, to find his declination.

> As the sine of 90 *gr.*
> to the cosine of the latitude:
> So the cosine of the azimuth from the meridian,
> to the sine of the declination.

And thus in our latitude of 51 *gr.* 30 *m.* when the azimuth is 80 *gr.* from the meridian, the declination will be found to be 6 *gr.* 12 *m*; if the azimuth be 70 *gr.* the declination will be found 12 *gr.* 18 *m*; if 60 *gr.* then 18 *gr.* 8 *m.* And so for the rest, which may be also set downe in the Table.

A Table for the altitude of the Sunne in the beginning of each Signe for euery tenth azimuth, in 51 gr. 30 m. of North latitude.

Az.	♋		♊ ♌		♉ ♍		♈ ♎		♓ ♏		♒ ♐		♑	
	Gr.	M	Gr.	M	Gr.	M.	Gr.	M	Gr.	M	Gr.	M.	Gr.	M.
0	62	0	58	42	50	0	38	30	27	0	18	18	15	0
10	61	43	58	24	49	38	38	4	26	30	17	45	14	25
20	60	51	57	28	48	33	36	46	25	0	16	5	12	41
30	59	52	55	52	46	40	34	34	22	27	13	35	9	45
40	57	10	53	29	43	55	31	21	18	48	9	14	6	34
50	54	3	50	12	40	11	27	5	13	58	3	57	0	6
60	49	56	45	53	35	23	21	41	8	0				
70	44	40	40	25	29	27	15	13	1	0				
80	38	11	33	46	21	29	7	52						
90	30	38	26	10	14	45	0	0						
100	22	27	18	2	6	45							6	12
110	14	14	9	58									12	18
120	6	34	2	30									18	8

That

That done, if you would draw the line of East or West, which is 90 *gr.* from the meridian, lay the ruler to the center *A*, and 30 *gr.* 38 *m.* numbred in the quadrant from *C* toward *B*, and note the point where it crosseth the tropique of ♋; then moue the ruler to 26 *gr.* 10 *m.* and note where it crosseth the parallell of ♊; then to 14 *gr.* 45 *m.* and note where it crosseth the parallell of ♉; then to 0 *gr.* 0 *m.* and you shall finde it to crosse the equator in the point *F*; so a line drawne through these points, shall shew the azimuth belonging to East and West. The like reason holdeth for all the rest.

These lines being thus drawne, if you set two sights vpon the line *A C*, and hang a thread and plummet on the center *A*, with a bead vpō the thread, the foreside of the quadrant shall be fully finished.

Or in stead of the fiue starres before mentioned, you may place the *Nocturnall* (described before in the vse of the *Sector, pag.* 60.) on the backside of the Quadrant, and so also it will be fitted both for day and night.

CHAP.

CHAP. II.

Of the vse of the Quadrant in taking the altitude of the Sunne, Moone, and Starres.

THe Quadrant is the fourth part of a circle, diuided equally into 90 *gr.* and here numbred by 10. 20. 30. &c. vnto 90 *gr.* each degree being subdiuided into 4.

Lift vp the center of the Quadrant, so as the thread with the plummet may play easily by the side of it, and the Sunne beames may passe through both the sights; so shall the degrees cut by the thread, shew what is the altitude at the time of obseruation, as may appeare by this example.

Vpon the 14 day of April, about noone, the Sun-beames passing through both the sights, the thread fell vpon 51 *gr.* 20 *m.* and this was the true meridian altitude of the Sun for that day in this our latitude of 51 *gr.* 30 *m.* for which this Quadrant was made.

Againe, towards three of the clocke in the afternoone, the thread fell vpon 38 *gr.* 40 *m.* and such was the Sunnes altitude at that time.

CHAP. III.

Of the Ecliptique.

1 *The place of the Sunne being giuen to finde his right ascension.*

THe Ecliptique is here represented by the arke, figured with the characters of the twelue Signes, ♈, ♉, ♊, &c. each Signe being diuided vnequally into 30 *gr.* and they are to be reckoned from the character of the Signe.

Let the thread be laid on the place of the Sunne in the Ecliptique, and the degrees which it cutteth in the Quadrant shall be the right ascension required.

As if the place of the Sunne giuen be the fourth degree of ♊, the thread laid on this degree ſhall cut 62 degrees in the Quadrant, which is the right aſcenſion required.

But if the place of the Sunne giuen be more then 90 *gr.* from the beginning of ♈, there muſt be more then 90 *gr.* allowed to the right aſcenſion; for this inſtrument is but a quadrant: and ſo if the Sunne be in 26 *gr.* of ♋, you ſhall finde the thread to fall in the ſame place, and yet the right aſcenſion to be 118 *gr.*

2 *The right aſcenſion of the Sunne being giuen, to find his place in the Ecliptique.*

Let the thread be laid on the right aſcenſion in the Quadrant, and it ſhall croſſe the place of the Sunne in the Ecliptique, as may appeare in the former example.

CHAP. IIII.

Of the line of declination.

1 *The place of the Sunne being giuen to find his declination.*

THe line of declination is here drawne from the center to the beginning of the Quadrant, and diuided from the beginning of ♈ downward into 23 *gr.* 30 *m.*

Let the thread be laid, and the beade ſet on the place of Sunne in the ecliptique; then moue the thread to the line of declination, and there the bead ſhal fall vpon the degrees of the declination required.

As if the place of the Sunne giuen be the fourth degree of ♊, the beade firſt ſet to this place, and then moued to the line of declination, ſhall there ſhew the declination of the Sunne at that time to be 21 *gr.* from the equator.

2 *The declination of the Sunne being giuen, to find his place in the Ecliptique.*

Let the thread and beade be first laid to the declination, and then moued to the Ecliptique.

As if the declination be 21 *gr.* the beade first set to this declination, and then moued to the ecliptique, shall there shew the fourth of ♊, the fourth of ♐, the *26* of ♋, and the *26* of ♑; and which of these foure is the place of the Sunne, may appeare by the quarter of the yeare.

CHAP. V.

Of the circle of Moneths and Dayes.

THis circle is here represented by the arke, figured with these letters, *I, F, M, A, M*, &c. signifying the moneths Ianuary, February, March, April, &c. each moneth being diuided vnequally, according to the number of the dayes that are therein.

1 *The day of the moneth being giuen, to find the altitude of the Sunne at noone.*

Let the thread be laid to the day of the moneth, and the degrees which it cutteth in the Quadrant shall be the meridian altitude required.

As if the day giuen be the 15 of May, the thread laid on this day shall cut 59 *gr.* 30 *m.* in the quadrant, which is the meridian altitude required.

2 *The meridian altitude being giuen, to finde the day of the moneth.*

The thread being set to the meridian altitude, doth also fall on the day of the moneth.

As if the altitude at noone be 59 *gr.* 30 *m.* the thread being set to this altitude, doth fal on the 15 day of May and the 9 of July; and which of these two is the true day, may be knowne by the quarter of the yeare, or by another dayes obseruation. For if the altitude proue greater, the thread wil fall on the 16 day of May and the 8 of July: or if it proue lesser, the thread will fall on the 14 of May and the 10 of July; whereby the question is fully answered.

CHAP. VI.

Of the Houre-lines.

THat arke which is drawne vpon the center of the quadrant by the beginning of declination, doth here represent the equator: that arke which is drawne by 23 *gr.* 30 *m.* of declination, and is next aboue the circle of moneths and dayes, representeth the tropiques: those lines which are betweene the equator and the tropiques, being vndiuided and numbred at the equator by 6.7.8.9.10.11.12. at the tropique by 1.2.3 4.&c. do represent the houre-circles: that which is drawne from 12 in the equator to the middle of Iune, representeth the houre of 12 at noone in the Summer; and those which are drawn with it to the right hand, are for the houres of the day in the Summer, and the houres of the night in the Winter. That which is drawne from 12 in the equator to the middle of December, representeth the houre of 12 in the Winter; and those which are drawne with it to the left hand, are for the houres of the day in the Winter, and the houres of the night in the Summer; and of both these, that which is drawne from 11 to 1, serues for 11 in the forenoone, and 1 in the afternoon. That which is drawne frō 10 to 2, serues for 10 in the forenoon, & 2 in the afternoon: for the Sun on the same day is about the same height two houres before noon, as two houres after noone. The like reason holdeth for the rest of the houres.

1 *The day of the moneth, or the height at noone being knowne, to finde the place of the Sunne in the Eclipt ique.*

The thread being laid to the day of the moneth, or the height at noone, (for one giues the other by the former proposition) marke where it crosseth the houre of 12, and set the bead to that intersection; then moue the thread till the bead fall on the ecliptique, and it shall fall on the place of the Sun.

As if the day giuen be the 15 of May, or the meridian altitude 59 *gr.* 30 *m.* lay the thread accordingly, and put the bead to the intersection of the thread with the houre of 12; then moue the thread till the bead fall on the ecliptique, and it shall there shew the fourth of ♊, the fourth of ♐, the 26 of ♋, and the 26 of ♑; and which of these is the place of the Sunne, may appeare by the quarter of the yeare, or another dayes obseruation.

2 *The place of the Sun in the Ecliptique being knowne, to finde the day of the moneth, &c.*

Let the thread and beade be first laid on the place of the Sunne in the Ecliptique, and then moued to the line of 12.

As if the place of the Sunne giuen be the fourth of ♊, the bead being laid to this degree, and then moued to the houre of 12, in the Summer, the thread will fall on the 15 day of May, and the 9 of Iuly; or if it be moued to the houre of 12 in the Winter, the thread wil fall on the 6 of Ianuary and the 16 of Nouember; which of these is the day of the moneth required, may appeare by the quarter of the yeare.

In this and the former propositions, you haue two wayes to rectifie the bead, by the place of the Sunne, and by the day of the moneth; the better way is by the place of the Sunne, for in the other the Leap-yeare may breed some small difference.

There is yet a third way. For the Sea-men hauing a table for the declination on each day of the yeare, may set the bead thereto in the line of declination.

3 *The houre of the day being giuen to find the altitude of the Sunne aboue the horizon.*

The bead being set for the time by either of the three ways, let the thread be moued from the houre of 12 toward the line of declination, till the bead fall on the houre giuen; and the degrees which it cuts in the Quadrant, shall shew the altitude of the Sunne at that time.

As if the time giuen be the tenth of April, the Sunne being then in the beginning of ♉, the bead being rectified, you shall finde the height at noone 50 *gr.* 0 *m.* at 11 in the morning 48 *gr.* 12 *m.* at 10 but 43 *gr.* 12 *m.* at 9 but 36 *gr.* at 8 but 27 *gr.* 30 *m.* at 7 but 18 *gr.* 18 *m.* at 6 but 9 *gr.* at 5 it meeteth with the line of declination, and hath no altitude at all, and therefore you may think it did rise much about that houre.

Then if you moue the thread again from the line of declination toward the houre of 12, you shal find that the Sun is 8 *gr.* 33 *m.* below the horizon at 4 in the morning, & neare 16 *gr.* at 3, and 21 *gr.* 51 *m.* at 2, and 25 *gr.* 40 *m.* at 1, and 27 *gr.* at midnight.

4 *The altitude of the Sunne being giuen, to finde the houre of the day.*

The altitude being obserued as before, let the bead be set for the time, then bring the thread to the altitude, so the bead shall shew the houre of the day.

As if the 10 of April hauing set the bead for the time, you shall finde by the quadrant, the altitude to be 36 *gr.* the bead at the same time will fall vpon the houre-line of 9 and 3: wherefore the houre is 9 in the forenoone, or 3 in the afternoone. If the altitude be neare 40 *gr.* you shall find the bead

at

at the same time to fall halfe way betweene the houre-line of 9 and 3, and the houre-line of 10 and 2: wherefore it must be either halfe an houre past 9 in the morning, or halfe an houre past 2 in the afternoone; and which of these is the true time of the day, may be soone knowne by a second obseruation: for if the Sunne rise higher, it is the forenoone; if it become lower, it is the afternoone.

5 *The houre of the night being giuen, to find how much the Sunne is below the horizon.*

The Sunne is alwayes so much below the horizon at any houre of the night, as his opposite point is aboue the horizon at the like houre of the day; and therefore the beade being set, if the question be made of any houre of the night in the Summer, then moue it to the like houre of the day in the Winter; if of any houre of the night in Winter, then moue it to the like houre of the day in Summer; so the degrees which the thread cutteth in the Quadrant shall shew how much the Sunne is below the horizon at that time.

As if it be required to know how much the Sunne is below the horizon the 10 of April at 4 of the clock in the morning; the bead being set to his place according to the time in the Summer houres, bring it to 4 of the clocke in the afternoone in the Winter houres, and so shall you finde the thread to cut 8 *gr.* and about 30 *m.* in the quadrant; and so much is the Sunne below the horizon at that time.

6 *The depression of the Sunne supposed, to giue the houre of the night with vs, or the houre of the day to our Antipodes.*

Here also because the Sun is so much aboue the horizon at all houres of the day, as his opposite point is below the horizon at the like houre of the night; therefore first set the bead according to the time, then bring the thread to the degree of the Suns depression below the horizon, so shall the bead

bead fall on the contrary houre-lines, and there shew the houre of the night in regard of vs, which is the like houre of the day to our Antipodes.

As if the 10 of April the Sunne being then in the beginning of ♉, and by supposition 8 *gr.* 30 *m.* below the horizon in the East, it be required to know what time of the night it is; first set the bead according to the day in the Summer houres, then bring the thread to 8 *gr.* 30 *m.* in the quadrant, so shall the bead fall among the Winter houres, on the line of 4 of the clocke in the afternoone: wherefore to our Antipodes it is 4 of the clocke in their afternoone, and to vs it is then 4 of the clocke in the morning.

7 *The time of the yeare or the place of the Sunne being giuen, to find the beginning of day-breake, and end of twi-light.*

This proposition differeth little from the former: for the day is said to begin to breake, when ẏ Sun cometh to be but 18 *gr.* below our horizon in the East, and twi-light to end when it is gotten 18 *gr.* below the horizon in the West: wherefore let the bead be set for the time, and then bring the thread to 18 *gr.* in the quadrant, so shall the bead fall on the contrary houre-lines, and there shew the houre of twi-light as before.

So if it be required to know at what time the day begins to breake on the tenth of April, the Sun being then in the beginning of ♉; first set the bead according to the time in the Summer houres, and then bring the thread to 18 *gr.* in the quadrant, so shall the bead fall among the Winter houres a little more then a quarter before 3 in the morning; and that is the time when the day begins to break vpon the tenth of April.

CHAP.

CHAP. VII.

Of the Horizon.

THe Horizon is here represented by the arke drawne, from the beginning of declination towards the end of February, diuided vnequally, and numbred by 10.20.30.40.

1 ***The day of the moneth, or the place of the Sunne being knowne, to finde the amplitude of the Sunnes rising and setting.***

Let the bead rectified for the time, be brought to the horizon, and there it shall shew the amplitude required.

As if the day giuen be the 15 of May, the Sunne being in the fourth degree of ♊, the bead rectified and brought to the horizon, shall there fall on 35 *gr.* 8 *m.* such is the amplitude of the Sunnes rising from the East, and of his setting from the West; which amplitude is alwayes Northward when the Sunne is in the Northerne Signes, and when he is in the Southward Signes alwayes Southward.

2 ***The day of the moneth, or the place of the Sunne being giuen, to finde the ascensionall difference.***

Let the bead rectified for the time, be brought to the horizon, so the degrees cut by the thread in the quadrant, shall shew the difference of ascensions.

As if the day giuen be the 15 of May, the Sunne being in the fourth degree of ♊, let the bead be rectified and brought to the horizon; so shall the thread in the quadrant shew the ascensionall difference to be 28 *gr.* and about 50 *m.*

Vpon the ascensionall difference depends this Corollarie.

To find the houre of the rising and setting of the Sun, and thereby the length of the day and night.

The time of the Sunnesrising may be guessed at by the 3 of the last *Cap.* but here by the ascensionall difference it may be better found, and that to a minute of time. For if the ascensionall difference be conuerted into time, allowing an houre for 15 *gr.* and 4 minutes of an houre for each degree, it sheweth how long the Sunne riseth before six of the clock in the Summer, and after six in the Winter.

As if the day giuen be the 15 of May, the Sunne being in the fourth of ♊, and his ascensionall difference found as before 28 *gr.* 50 *m*; this conuerted into time, maketh 1 *ho.* and somewhat more then 55 *m.* of an houre: wherefore the Sun at that time, in regard it was Summer, rose 1 *ho.* and full 55 *m.* before 6 of the clocke; and so hauing the quantitie of the semidiurnall arke, the length of the day and night need not be vnknowne.

CHAP. VIII.

Of the fiue Starres.

I Might haue put in more Starres, but these may suffice for the finding of the houre of the night at all times of the yeare: and first I make choice of *Ala Pegasi*, a starre in the extremitie of the *wing of Pegasus*, in regard it wants but 6 minutes of time of the beginning of ♈; but because it is but of the second magnitude, and not alwayes to be seene, I made choice of foure more, one for each quarter of the Ecliptique, as of *Oculus* ♉ the Buls eye, whose right ascension conuerted into time, is 4 *ho.* 15 *m*; then of *Cor* ♌ the Lions heart, whose right ascension is 9 *ho.* 48 *m*; next of *Arcturus*, whose right ascension is 13 *H.* 58 *m*; and lastly of *Aquila*, or the Vultures heart, whose right ascension is 19 *H.* 33 *m.* These fiue starres haue all of them Northern declination; and if any others, some of these will be seene at all times of the yeare.

The

The vſe of them is,

The altitude of any of theſe fiue Starres being knowne, to find the houre of the night.

First put the beade to the ſtarre which you intend to obſerue, take his altitude, and finde how many houres he is from the meridian by the fourth *Prop.* of the ſixt *Chap*; then out of the right aſcenſion of the ſtarre, take the right aſcenſion of the Sun conuerted into houres, and marke the difference; for this difference being added to the obſerued houre of the ſtarre from the meridian, ſhall ſhew how many houres the Sunne is gone from the meridian, which is in effect the houre of the night.

As if the 15 of May, the Sunne being in the fourth of ♊, I ſhould ſet the beade to *Arcturus*, and obſeruing his altitude ſhould find him to be in the Weſt about 52 *gr.* high, and the beade to fall on the houre-line of 2 afternoone, the houre would be 11 *ho.* 50 *m.* paſt noone, or 10 *m.* ſhort of midnight.

For 62 *gr.* the right aſcenſion of the Sunne, conuerted into time, makes 4 *ho.* 8 *m.* which if we take out of 13 *ho.* 58 *m.* the right aſcenſion of *Arcturus*, the difference will be 9 *ho.* 50 *m.* and this being added to 2 *ho.* the obſerued diſtance of *Arcturus* from the meridian, ſhewes the houre of the night to be 11 *ho.* 50 *m.* Another example wil make all more plaine.

If the 9 of Iuly the Sunne being then in 26 *gr.* of ♋, I ſhould ſet the beade to *Oculus* ♉, and obſeruing his altitude ſhould find him to be in the Eaſt about 12 *gr.* high, and the bead to fall on the houre-line of 6 before noone, which is 18 *ho.* paſt the meridian, the houre of the night would be better then a quarter paſt 2 of the clocke in the morning.

For 118 *gr.* the right aſcenſion of the Sun, conuerted into time, makes 7 *ho.* 52 *m*; this taken out of 4 *ho.* 15 *m.* the right aſcenſion of *Oculus* ♉, adding a whole circle, (for otherwiſe there could be no ſubſtraction) the difference will be 20 *ho.* 23 *m.* and this being added to 18 *ho.* which was the obſerued diſtance of *Oculus* ♉ from the meridian, ſhewes that the Sun

(abating 24 *ho* for the whole circle) is 14 *gr.* 23 *m.* past the meridian, and therefore 23 *m.* past 2 of the clock in the morning.

CHAP. IX.

Of the Azimuth lines.

THose lines which are drawne betweene the equator and the tropiques, on that side of the quadrant which is nearest vnto the sights, and are numbred by 10. 20. 30. &c. doe represent the azimuths, the vttermost to the left hand representeth the meridian, that which is numbred with 10 the tenth azimuth from the meridian, and that which is numbred with 20 the twentith, and so the rest. Those lines which are drawne from the equator to the left hand, doe shew the azimuth in the Summer; and those other to the right hand, do shew the same in the Winter. The vse of them is,

1 *The azimuth whereon the Sunne beareth from vs being knowne, to find the altitude of the Sun aboue the horizon.*

First let the bead be set for the time, as in the former Chapter, then moue the thread vntill the bead fall on the azimuth; so the degrees which the thread cutteth in the quadrant, shall shew the altitude of the Sun at that time. Where you are to obserue, that seeing the azimuths are drawne on the right side of the quadrant, you are also to begin to number the degrees of the Sunnes altitude from the right hand toward the left. As if the sights had been set on the line *A B*, and you had turned your right hand towards the Sunne in obseruing of his altitude, contrary to our practise in the former Chapter.

July 12

As if the time giuen were the 2 of August, when the Sun hath about 15 *gr.* of North declination, you may set the bead for the time, so you shall find the height at noone when the Sunne

Sunne is in the South, to be 53 *gr.* 30 *m.* when he is 10 *gr.* from the South 53 *gr.* 10 *m.* when 20 *gr.* then about 52 *gr.* 8 *m.* when 30 *gr.* then 50 *gr.* 20 *m.* when 40 *gr.* then 47 *gr.* 48 *m.* when 50 *gr.* then 44 *gr.* 12 *m.* when 60 *gr.* then 39 *gr.* 35 *m.* when 70 *gr.* then 33 *gr.* 50 *m.* when 80 *gr.* then 27 *gr.* when he is in the East or West 90 *gr.* from the meridian, then is the height neare 19 *gr.* 20 *m*; when he comes to be 100 *gr.* then 11 *gr.* 15 *m.* when 110 *gr.* then 3 *gr.* 20 *m*; and before he commeth to the azimuth of 120 *gr.* he hath no altitude. For the Sunne hauing 15 *gr.* of North declination, will rise and set at 114 *gr.* 34 *m.* from the meridian.

2· *The altitude of the Sunne being giuen, to find on what azimuth he beareth from vs.*

Let the beade be set for the time, and the altitude obserued as before; then bring the thread to the complement of that altitude, so the bead shall shew the azimuth required.

As if the second of August, hauing set the beade for the time, you shall find the altitude of the Sun to be 19 *gr.* 20 *m.* remoue the thread vnto 70 *gr.* 40 *m.* the complement of the altitude; or, which is all one, to 19 *gr.* 20 *m.* from the right hand toward the left, and the bead will fall on the line of 90 *gr.* from the meridian. And therefore the point whereon the Sunne beareth from vs, is one of these two, either due East or due West. And which of these is the true point of the compasse, may be soone knowne by a second obseruation: for if the Sun rise higher, it is the forenoone; if it be lower, it is the afternoone.

By knowing the azimuth or point of the compasse whereon the Sunne beareth from vs, it is easie to finde,

A meridian line; and thereby
The coasting of the Countrey.
The site of a building.
The variation of the Compasse.

As if the second of August in the afternoone, I should find by the height of the Sunne that he beares from me 60 *gr.* from the meridian toward the West; then there being 90 *gr.* belonging to each quarter, the West will be 30 *gr.* to the right hand, the East is opposite to the West, the North and South lie equally betweene them.

CHAP. X.

Of the Quadrat.

THe Quadrat hath two sides diuided, the other two sides next the Center may be supposed to be diuided, each of them into 100 equal parts: of the sides diuided, that which is next the horizontall line containes the parts of right shadow, the other next the sights, the parts of contrary shadow. The vse of the Quadrat is,

1 *Any point being giuen, to finde whether it be leuell with the eye.*

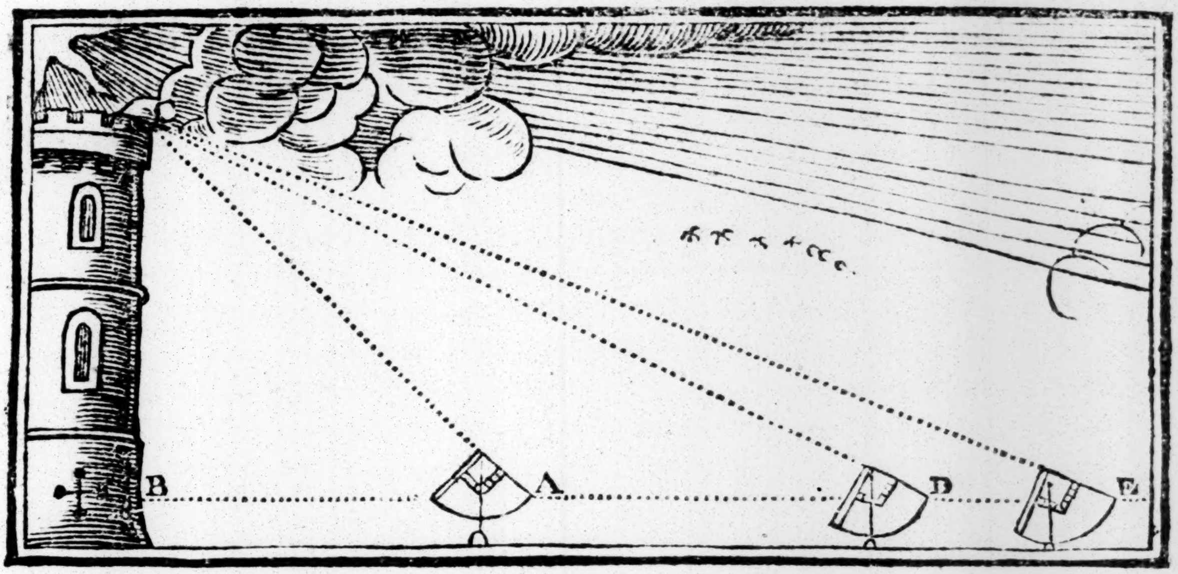
Lift vp the center of the quadrant, so as the thread with the plummet may play easily by the side of it; then looke through the sights to the place giuen: for now if the thread shall fall on *A B* the horizontall line, then is the place giuen leuel with the eye: but if it shal fal within the said line on any of the diuisions, then it is higher; if without, then it is lower then the leuell of the eye.

2 *To find an height aboue the leuell of the eye, or a distance at one obseruation.*

Looke through the sights to the place, going nearer or farther from it, till the thread fall on 100 parts in the quadrat or 45 *gr.* in the quadrant, so shall the height of the place aboue the leuell of the eye, be equall to the distance between the place and the eye.

If the thread fall on 50 parts of a right shadow, the height

is



is but halfe the distance: if it fall on 25, it is a quarter of the distance: if on 75, it is three quarters of the distance. For as oft as the thread falleth on the parts of right shadow,

As 100 to the parts on which the thread falleth:
So is the distance to the height required.

And on the contrary,

As the parts cut by the thread are to 100:
So the height vnto the distance.

But when the thread shall fall on the parts of contrary shadow: if it fall on 50 parts, the height is double vnto the distance; if on 25, it is foure times as the distance. For as oft as the thread falleth on the parts of contrary shadow,

As the parts cut by the thread are vnto 100:
So is the distance vnto the height.

And on the contrary,

As 100 are vnto the parts cut by the thread:
So is the height vnto the distance.

And what is here said of the height and distance, the same may be vnderstood of the height and shadow.

3 *To find a height or a distance at two obseruations.*

As if the place which is to be measured might not other-

wise

wise be approched, & yet it were required to find the height *B C*, and the distance: first if I make choice of a station at *A*, where the thread may fall on 100 parts in the quadrat, and 45 *gr.* in the quadrant, the distance *A B* will be equall to the height *BC*; then if I go farther in a direct line with the former distance, and make choice of a second station at *D*, where the thread may fall on 50 parts of right shadow, the distance *BD* would be double to the height *BC*: wherefore I may measure the difference betweene the two stations *A* and *D*, and this difference *A D* will be equall both to the distance *A B* and the height *BC*.

Or if I cannot make choice of such stations, I take such as I may, one at *D*, where the thread falleth at 50 parts of right shadow; the second at *E*, where it falleth on 40 parts: and supposing the height *B C* to be 100, I find that

As 50 parts are vnto 100, the side of the quadrat:
So 100 the supposed height, vnto 200 the distance *BD*
And as 40 parts, at the second station, vnto 100:
So 100 the supposed height, vnto 250 the distance *BE*.

Wherfore the difference betweene the stations *D* & *E* should seeme to be 50; and then if in measuring of it, I should find it to be either more or lesse, the proportion will hold, as from the supposed difference to the measured difference, so from height to height, and from distance to distance.

As if the difference betweene the two stations *D* and *E* being measured, were found to be 30.

As 50 the supposed difference, vnto 30 the true difference:
So 100 the supposed height, vnto 60 the true height.
And 200 the supposed distance, vnto 120 the true distãce:
And 250 at the second station, vnto 150 the distance *B E*.

The like reason holdeth in all other examples of this kind: and if an Index with sights were fitted to turne vpon the Center, it might then serue by the same reason for the finding of all other distances.

FINIS.

3 : l
1 : l

6

L..Or

umber, -.

BOOK TURNED UPSIDE
DOWN FOR THIS EXPOSURE
FOR THE CONVENIENCE OF
THE READER.

Remarks upon Sutton's Quadrant

For drawing the Equator the same as Gunter viz
make from the Centre (=C) to 67 Radius on the Sector [illegible]
or 1000 eq. pts and C♈ will be 655 of those parts and
C♑ will be 430 of those parts

The same Extent of Compasses which describes the [illegible]
lower part of the Ecliptic will also describe the
upper part whose Center will fall some where off the
Quadrant

~~The Horizon is describ'd the same as the Center ... the~~
The ~~upper Horizon~~

The upper Horizon is described with the same Extent
of the Compasses which cuts the Tropic of ♑ in 36° [illegible] the
same as the lower Horizon cuts the Tropic of ♋

BOOK NOW RETURNED
TO NORMAL POSITION.

°	′	″
0	13	45
24	46	15
25	34	45
42	05	15
52	54	30
65	06	00
75	20	15
80	33	30
85	03	15
98	11	00
111	08	30
112	04	00
128	05	30
148	14	45
173	30	00
180	09	30
181	49	15
197	22	00
210	24	30
218	34	30
225	10	30
232	[illegible]	45
242	44	30
260	01	00
276	16	30
293	43	15
321	58	45
342	01	45
359	00	15
357	46	45